Water spectrum

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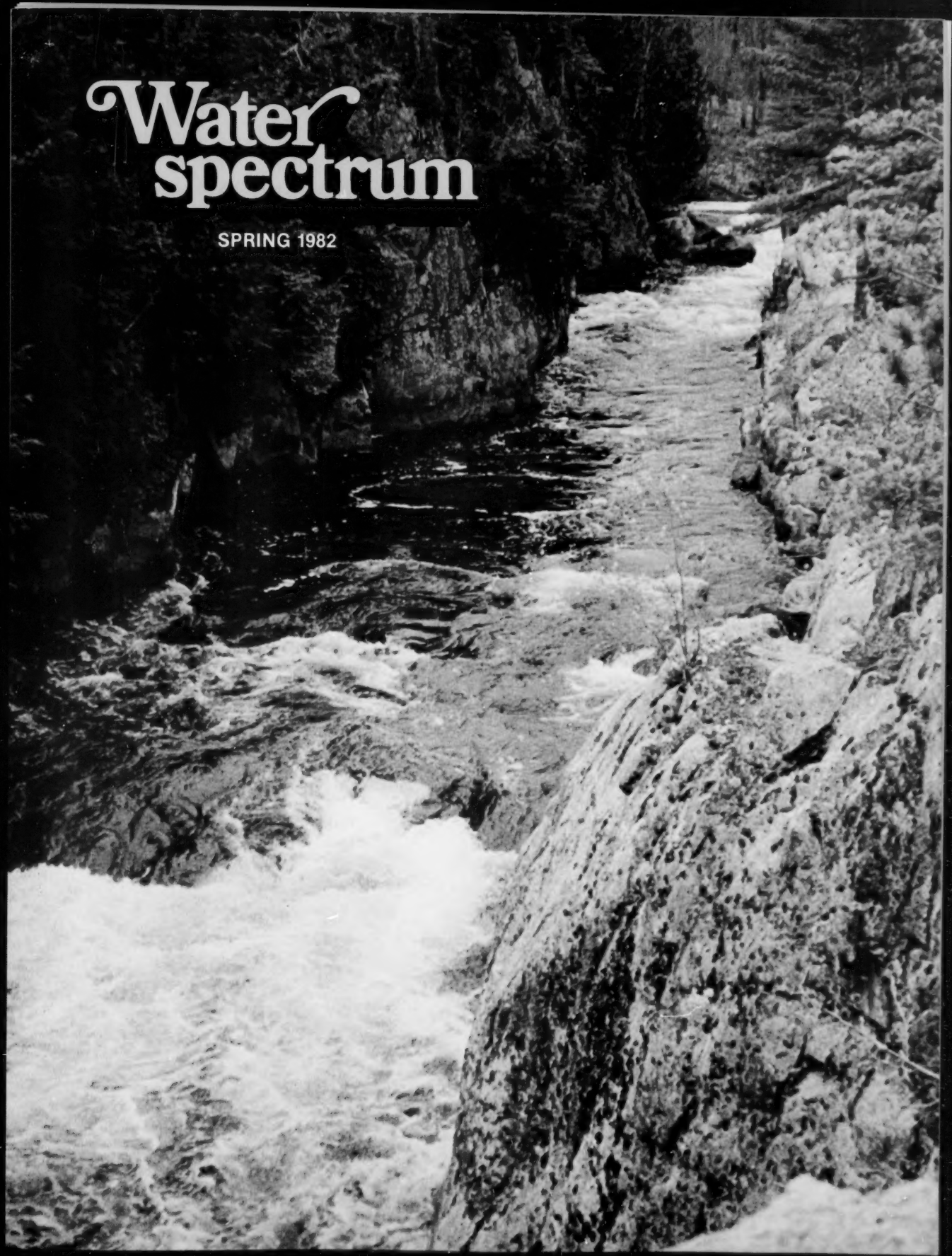

Water spectrum

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COVER: "April prepares her green traffic light and the world thinks Go."
—Christopher Morley

(Photo by Tom Williams, Bureau of Indian Affairs; from U.S. Department of the Interior Conservation Yearbook Series No. 10, 1974.)

INSTITUTIONAL BARRIERS TO NATIONAL WATER POLICY

by David C. Harrison

Institutional barriers to integrated water resource *management* are generally well documented. They include: artificially low water prices which discourage conservation and create shortages; legal obstacles to the transfer of surface water rights in California and other western states from low-value cash crops to high-value crops or other beneficial uses; lack of coordination between the Federal government and the states and between the states and local governments, which prevents integrated ground and surface water management; a water policy conflict between the previous administration and the Congress, which contributed to further delays in Federal water project authorizations (project implementation already averages 26 years for Federal flood control proj-

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Mr. Harrison is currently project director and consultant to the National Academy of Public Administration, Washington, D.C. 20036, where he is working to bring together various levels of government and private concerns to organize a constituency-based institutional reform process and water policy structure. This article is adapted from a draft paper prepared by Mr. Harrison for the use of the American Association for the Advancement of Science as part of a project which provided background materials for the *Fourth Annual Science and Technology Report.*

ects); lack of coordination among Federal programs and between Federal and state programs, which prevents integrated water quantity and water quality management; inconsistent Federal cost sharing arrangements for water projects; and overlapping or conflicting agency missions, laws, and programs, and fragmented Congressional committee responsibilities. (*See "Planning Versus Implementation: The Story of the Seventies," in* Water Spectrum, *Vol. 14, No. 1, Winter 1981–82.*)

Institutional barriers to national water *policy* are less well understood. A review of the progress and problems experienced by the institutional structure established by the Water Resources Planning Act of 1965 will show that the act strengthened intergovernmental roles and relationships, primarily between the state and Federal levels. It authorized Federal interagency and Federal-interstate policy making and coordinating mechanisms. It also provided Federal financial support for statewide comprehensive planning and coordination, thus materially strengthening many states' water management capabilities.

Implementation of the act revealed the presence of continuing institutional barriers to water policy both on a national and on a regional scale. These eventually led to the abandonment of the institutional structure created by the act. At the Federal level, the Water Resources Council provided a useful mechanism for interagency coordination and communication. It was unable, however, to address major water policy conflicts or, when it attempted to do so, to commit its members to collective policy decisions. The council tended to function outside the main cabinet structure and lacked accountability. It similarly operated without strong ties to non-Federal interests and thus possessed neither accountability nor a strong constituency within the Federal executive branch or outside of it. Its role in Federal water project decisions was perceived to be negligible until it produced project planning guidelines and was directed to perform an independent project review function on the basis of its guidelines, and then it was perceived to be obstructive.

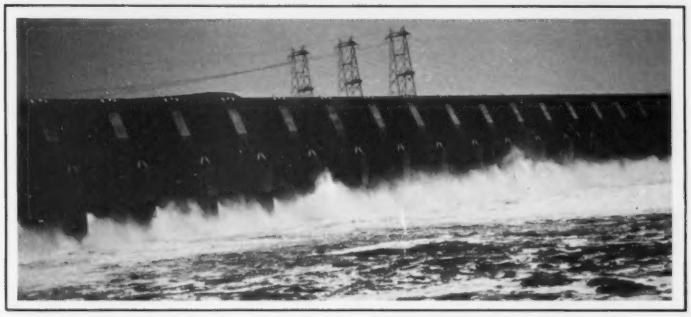
Comprehensive management plans for interstate river basins provided useful sources of information and resolved major water policy conflicts while participating states and Federal agencies were committed to the planning process. But they did not commit the intergovernmental structure to collective policy or to plan implementation, as they were intended, or to the performance of a continuing policy guidance function. A participating agency, for example, might approve the adoption of a river basin plan by a river basin commission and subsequently recommend management measures for local or Congressional approval that would comply with its legislative mandate but conflict with the river basin plan. Or the planning process would omit certain issues or considerations, such as minimum flow requirements for power generation and other uses, because an agency or utility did not participate or because its interests are fixed by law and therefore not subject to change through a flexible policy guidance process. Where serious interstate conflicts arose, for example, over proposed inter-basin water diversions, member states might choose to maintain a policy vacuum in anticipation that the issue would reach the Supreme Court rather than refer it to planning machinery that could not reach binding agreements.

The urgency of dealing with water resource problems today comes from their increasing severity and the perception that institutional barriers, perhaps more than technology, prevent solutions. It also comes from the change in administrations and economic conditions which open up the opportunity to make fundamental changes in institutional and intergovernmental roles and relationships. Both the need and the opportunity are present to strengthen the role of non-Federal interests—the states, local governments, and private sector—in national water policy. For the management of the nation's water resources is primarily a non-Federal responsibility. A fundamental issue is whether this can be done flexibly, in ways that will recognize and preserve regional differences.

ABOVE: The urgency of dealing with water resource problems today comes from their increasing severity and the perception that institutional barriers, perhaps more than technology, prevent solutions. (Corps of Engineers photos.)

TOP RIGHT: Implementation averages 26 years for Federal flood control projects.

BOTTOM RIGHT: The planning process would omit certain issues or considerations, such as minimum flow requirements for power generation and other uses, because an agency or utility did not participate or because its interests are fixed by law and therefore not subject to change through a flexible policy guidance process.



WATER POLICY PROCESS

Policy describes rules or guiding principles that evolve from the resolution of conflicts between competing values or needs. For example, the conflict between the need to prevent loss of life and property damage from flood hazards in downstream communities, and the need to prevent environmental and social disruption from dam construction in upstream communities, might be resolved by a policy that generally rejects dams in favor of local protection works or nonstructural measures such as improved flood warning and community preparedness, or selective relocation and floodproofing over time.

A policy that is relied upon to guide decisions in any one situation represents a choice among competing economic, environmental, and social considerations to determine the outcome for these circumstances. For example, resource conflicts between navigation and commercial fishing interests where the location of a navigation channel may destroy part of an oyster bed create the need for guidance and at the same time create the considerations—competing social values that airse from beneficial and adverse impacts—that will provide guidance. The application of these values to resolve issues as they occur, through the selection of controlling values or "policies" for each issue, describes the overall policy guidance process. National economic development today will usually be the controlling consideration in policy conflicts, viewed from a national perspective.

A government that provides adequately for the development and application of policy guidance can anticipate and plan for future water supply, flood management, or other crises. It can then apply the considerable administrative and other costs of dealing with crises toward the realization of economic or other needs. Additional economies are achieved through the resolution of resource management conflicts at appropriate levels of government, starting with the lowest possible level, and through coordinated management of regional surface and groundwater systems.

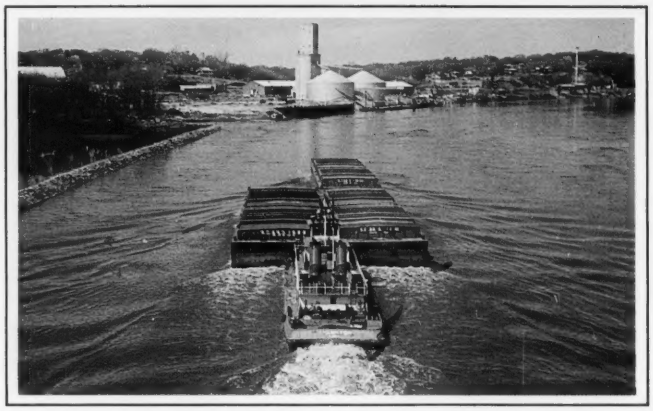
POLICY GUIDANCE FOR WATER RESOURCES SYSTEMS

The process begins with recognition that water resource systems—rivers and their interconnected tributary systems, groundwater aquifers, and related lands—are better managed as systems. Moreover, public needs associated with these systems are best served collectively, because water resource systems are shared resources and cannot meet the needs of one interest, or constituency, without affecting the needs of others. The process "integrates" water management by identifying, for every conflict between competing needs or values, a controlling consideration—some economic, environmental, or social value—that represents the highest public good for those circumstances.

The means generally do not exist for identifying public values and for applying them to resolve water policy conflicts within a watershed context on a sustained basis. This causes disatisfaction with the water policy process as a whole and specifically with procedures for planning and authorizing water development projects. Time, expense, and effort invested in the development and frequent revision of management planning procedures are substantially wasted because these procedures do not occur within the overall context of a policy guidance process.

Existing procedures and institutions for developing water projects place various obstacles in the path of determining appropriate controlling considerations or policies in the broad public interest. The nation's water policy structure has generally evolved piecemeal from specific needs, such as irrigation for agriculture and flood damage reduction, and governmental responses. it is an accumulation of things grafted onto one another rather than a structure designed and built rationally from the ground up, and therefore may lack an internal logic that is relevant to today's needs. The flow of institutional resources—legal authorities, technical competence, and

especially money—from higher to lower levels of government, from management agencies to affected local constituencies, tends to withhold responsibility and competence from local governments and bias the outcome in favor of project development values. Project subsidies and inconsistent cost-sharing arrangements between Federal, state, and local governments make it difficult for local interests to weight alternative policy choices properly on the basis of what they are willing and able to pay for them. Existing procedures promote agency responses to individual interests and make it difficult to tie policy choices to their comparative net social worth, *all* things considered.



THE LOCAL ROLE IN WATER POLICY

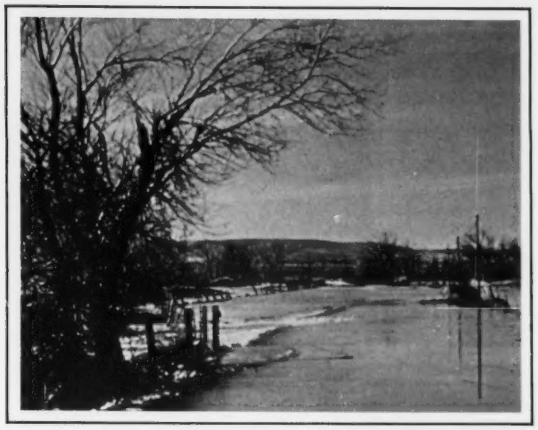
The policy guidance process in theory determines what needs to be said about resource management conflicts, and the institutional structure creates a voice, at appropriate levels, to say it. The nation's present water policy structure has a top-down rather than a bottom-up orientation. This is manifested in repeated legislative and administrative attempts to extract national policy guidance from collections of management agencies at the Federal level. That these attempts have not been successful is partly attributable to a conception of the policy process that emphasizes its role in imposing discipline from the top down without recognizing that it originates with affected interests from the bottom up. The consequence is continued public focus on the roles of the Federal government and the states in the process, where mission-oriented management agencies dominate, and comparative inattention to the role of local and substate regional governments, where water-using constituencies, or affected interests, dominate.

The local role in water policy tends to be limited in practice to public participation in project planning performed by the Federal construction or regulatory agencies and their state counterparts. Regional impact evaluations of management alternatives such as inter-basin water transfers or hydropower projects cannot fully satisfy the need for a broad policy guidance process for whole water resource systems when the scope of the analysis—and usually its outcome—are determined by the specific legislative mandates of the sponsoring agencies. Viewed in the context of the water policy process as a whole, "public participation" in agency planning begins not with the inception of a management plan but with the institution of a continuing policy guidance process.

If it were fully operational, the process might function as a separate component of an integrated water policy process under the overall guidance and control of public constituencies. Since policy emanates from affected interests, it could provide a tool that they can use to assert their values within all phases of the policy process and at all levels of the institutional structure, to guide and control management actions that affect their regional water resources systems cumulatively over time.

An important institutional barrier to national water policy is the uneven capability of the states to provide a state layer in the structure. A majority of the states lack statewide water policy, and in those states the determining factor may be the absence of a policy guidance process that is built from the level of cities and towns, counties, and substate regional planning agencies up to the state level. Recognition that state water policy constitutes the foundation for national water policy necessarily implies that the foundation for state policy—and for the structure as a whole—is local and substate regional policy.

At the Federal level the interagency coordinating apparatus established by the Water Resources Planning Act—the Water Resources Council—was unable to commit its member agencies to compliance with resource management policies contained in approved river basin plans. Congress provides legal authorities and financing for Federal water development projects and programs; underlying considerations seldom arise from a regional policy guidance process, or even, in many instances, from the management planning process.



ABOVE: A government that provides adequately for the development and application of policy guidance can anticipate and plan for future water supply, flood management, or other crises.

TOP LEFT: The conflict between the need to prevent loss of life and property damage from flood hazards in downstream communities, and the need to prevent environmental and social disruption from dam construction in upstream communities, might be resolved by a policy that generally rejects dams in favor of local protection works or nonstructural measures.

BOTTOM LEFT: Resource conflicts between navigation and commercial fishing interests create the need for guidance and at the same time create the considerations — competing social values that arise from beneficial and adverse impacts — that will provide guidance.

The nation has developed detailed procedures for product-oriented water project planning and implementation but now needs to develop a continuing process for anticipating and resolving water policy conflicts from the local level up that considers their cumulative impacts on the resource base over time, and on the collective local and other interests who share the resource. How should the policy process be defined? How should the institutional structure for the flow of policy from lower to higher levels be designed? How should the institutional structure for the flow of resources from higher to lower levels be designed? What water policy process does the nation want, and what institutional support structure is needed to make it work?

If conventional research and political processes cannot address these issues adequately, how should the collaborative reform process and supporting institutional analysis be designed so that these issues can be adequately addressed? Who should participate and in what setting can their roles in the policy process be examined?

WATER POLICY STRUCTURE

The institutional structure for national water policy consists of three main components. One is the different levels of government. Another is the public and private sectors. The third is management agencies and public constituencies—the various water users and other interests served by the agencies and represented through elected officials. The performance of the institutional structure raises four basic questions about the allocation of organizational roles and relationships:

1. Does the nation have the organizational capacity to generate policy guidance for watershed management—does it have the capacity to *govern* regional water resource systems that cross state and local boundaries?
2. Does the nation have the organizational capacity at the national level to perform a policy guidance function?
3. Do management agencies and public interests have proper roles in the policy guidance function?
4. Do the states and local governments have the institutional infrastructure they need—the organizations, procedures, technical competence, and money—to assume greater responsibility for water policy and water resources management?

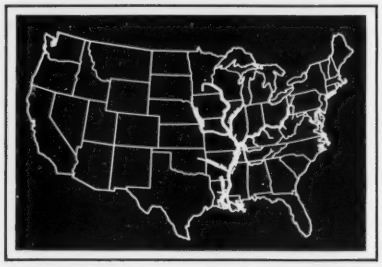
CAPACITY TO GOVERN WATERSHEDS

The definition of the policy guidance process used herein implies the need for an organizational role that is not generally found within the nation's river basins. Organizational arrangements developed for water resource management on a river basin scale, including Title II river basin commissions established under the Water Resources Planning Act, for the most part focus on management or project planning and usually are controlled by management agencies rather than local governments and other constituencies.

The organizational role that is generally missing potentially provides a foundation for the entire water policy structure. In theory it would perform a number of essential functions:

- Identify and resolve water policy conflicts at the lowest point possible in the organizational structure where this can be done within the context of unified river system management;
- Transfer conflicts up to higher layers in the structure that involve larger regional issues that go beyond the boundaries of the water resource system or are of larger than local or regional significance, such as inter-basin transfers or major industrial facilities;
- Link the policy guidance function with management planning and the project authorization and funding process;
- Integrate water with growth management, and conservation with economic development;

- Apply a comprehensive basinwide perspective to individual management decisions, giving due consideration to their cumulative impacts upon the water resources system over time and to the interests of the collective constituencies who share the watershed;
- Provide an appropriate institutional home for watershed constituencies through flexible arrangements for inter-local cooperation, and give them a means of speaking with one voice and dealing with other levels of the water policy structure. It is only among general-purpose local governments collectively that a perspective can be found that covers every aspect of river system management and that is not bound by the limited mandates of management agencies, by state boundaries, or by special interests;
- Create a base of local leadership at the inter-local level from which to build a watershed constituency;
- Provide a mechanism that allows local constituencies to assert their values and to assert appropriate control over the water policy process within their watershed, subject only to overriding considerations at higher levels in the structure;
- Provide policy guidance for the determination of water project priorities.



Rivers and their interconnected tributary systems, groundwater aquifers, and related lands are better managed as systems.

ORGANIZATIONAL CAPACITY AT THE NATIONAL LEVEL

A national water policy entity would have to represent broadly the different levels of government and other major interests that make up the structure as a whole to give it a national perspective on the issues. Congress is a lead water policy institution with a broad, national constituency. However, the National Water Commission found that its internal organization and procedures, particularly the Federal water project authorization process, tend to inject a fragmenting rather than a unifying influence into the policy process, and these conditions have remained essentially unchanged since publication of the commission's report (*Water Policies for the Future,* 1973).

The Cabinet Council on Natural Resources and the Environment, chaired by the president, provides a mechanism for Federal interagency coordination. It places the Federal water establishment more fully under the direction and control of the president than the Water Resources Council had been. It has a greater capacity to resolve major interagency conflicts than that council, but is viewed by non-Federal interests as being less accessible. The Cabinet Council is not designed to develop and implement national water policy. It represents elements of the Federal executive branch. It does not represent non-Federal interests such as the states and local governments and therefore cannot resolve policy conflicts between states or regions; apply policy guidance to promote intergovernmental cooperation; or assert a collective discipline over the entire national water policy structure in the *national,* as opposed to the *Federal,* interest.

Organizational changes that are under consideration in the Congress—specifically the creation of a national water policy board—raise the question whether an entity with a national perspective can be created through modifications to the Federal interagency apparatus established by the Water Resources Planning Act, or whether an entity that is more broadly representative of national water policy constituencies is needed. Specifically, would it be feasible to create an entity that represents state and local perspectives as well as Congress and the administration? That represents different regions, the private sector, environmental interests, and other perspectives? It is necessary?

ROLES OF MANAGEMENT AGENCIES AND PUBLIC INTERESTS

The Water Resources Council and Title II river basin commissions were said to be "all things to all people." They were given policy guidance and management planning responsibilities under the Water Resources Planning Act and were criticized alternately for doing too much of both or none of

LEFT: The nation's water policy structure has generally evolved piecemeal from specific needs, such as irrigation for agriculture and flood damage reduction, and governmental responses.

BOTTOM LEFT: The system has evolved largely in response to Federal categorical grant programs and project subsidies, which encouraged a damaging dependence on Federal grants and a distortion of the policy process.

either. The fault did not lie so much with their chairmen, their membership, their level of participation, their funding, or their personalities, as some have found. They were miscast.

Experience with the agency-based institutional structure established under the Water Resources Planning Act raises the question whether a policy guidance function can—or should—be combined with a management function in the same agency. For the Water Resources Council and river basin commissions were composed of management agencies, and were not representative of local governments or private interests. The assignment of primary policy guidance responsibility to the bureaucracy, rather than to representative, constituency-based institutions, violates basic democratic principles. It potentially alienates large segments of the institutional structure and undermines its political support. It could result in a demoralized bureaucracy as well as an unreceptive public.

The Water Resources Planning Act lost support perhaps because it demanded too much of management agencies and asked too little of public constituencies, particularly local governments. The agencies accepted their assignments and may have showed by their performance that their assignments placed them in an inappropriate role in the water policy process. The question this raises is how the relationship between management agencies and constituencies at all levels can be recast so that the contributions of each can be linked appropriately without being combined. What procedures and institutional forms will insure that the agencies' technical competence, powers, and institutional resources can be used to the fullest, without their encroaching on the public policy process? What arrangements will place the main actors in an appropriate relationship with one another so that the structure as a whole will increase its productivity and thereby increase the power of all of its components?

STATE AND LOCAL INFRASTRUCTURE

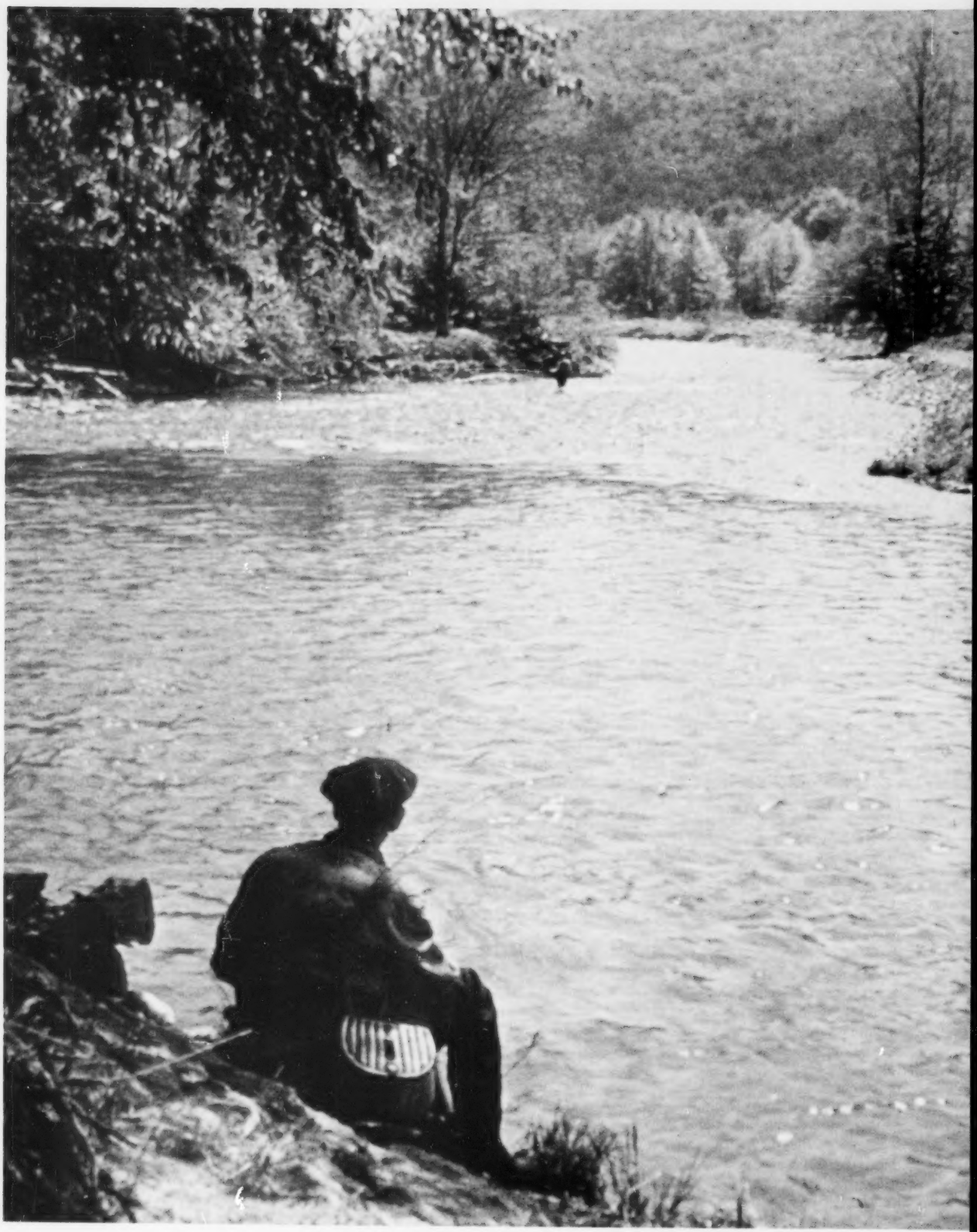
The Federal government has impeded institution building at the state and local levels through its generous water project subsidies and limited planning assistance. The system has evolved largely in response to Federal categorical grant programs and project subsidies, which encouraged a damaging dependence on Federal grants and a distortion of the policy process. Federal withdrawal provides an opportunity for the structure to evolve in different ways, from the bottom up.

A system where beneficiaries pay for water resource management is conducive to more local autonomy—to the development of a policy guidance process for water management controlled collectively by local governments and other interests that share regional water resource systems. Local governments in general are in a stronger position if they pay part of the cost. The water policy process and institutional support structure would be placed on a firmer footing if local governments did not rely entirely upon the states and Federal government to pay the costs.

Local constituencies that share regional water resource systems have a sensitive role to play in the water policy process but are poorly equipped politically, technically, and financially to assert their collective interests. Unless they receive encouragement, guidance, and assistance from higher levels, these systems may continue to constitute missing links in the policy structure and remain serious institutional barriers to national water policy.

Leadership would most logically come from state legislatures in establishing inter-local water policy structures within hydrological units. The states, in turn, need guidance, encouragement, and assistance from the Federal level to remove institutional barriers that now prevent them from doing this.

The present administration's shift away from Federal subsidies to private support for projects could open the way to new financing mechanisms for policy if means could be found to share project support with policy support. Can the creative thought that has been invested in finding private funding for water projects also find alternative sources of funding to support the water policy process? ■



Rain soaks easily into undisturbed forests and follows rivulets to nearby streams.
(U.S. Forest Service photos.)

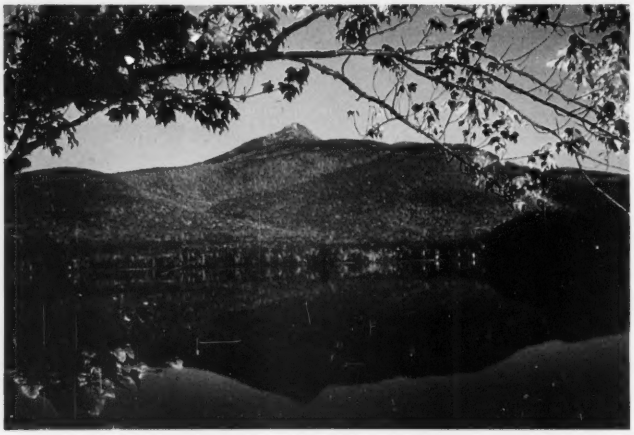
CAN FORESTS PROVIDE MORE WATER?

by James H. Patric and James O. Evans

Since Biblical times, people have known forested regions as "a fertile land, a land that has rivers and springs, and underground streams gushing out into the valleys. . ." And why not? Trees grow best where rain is plentiful. Recently we have learned that forests consume a lot of the rain but that they can be managed to consume less water and thereby to yield more for use by people. Nevertheless, few realize the forest's full potential as a supplier of water. So recent is this knowledge that its entire evolution can be traced in the scientific writing of the past 100 years.

Because people have always observed cool, clear water issuing abundantly and regularly from forested land, it seems scarcely surprising that land clearing has long been perceived a threat to water supplies. Soon after the Civil War, a report on forestry (Frankin Hough) deplored that "our streams diminish as the woodlands are cut away," and George Marsh declared that "the felling of the woods. . . attended with momentous consequences . . . to the . . . configuration of [the soil] surface." Major floods at the turn of the century were attributed by L.C. Glenn (U.S. Geological Survey) to deforestation of the Appalachians. This thinking—that forests maximize water supply even as they prevent soil erosion and flooding—is implicit in the Weeks Law of 1911, which authorized the acquisition of cutover land to form certain National Forests in the east, primarily to protect water supplies.

Mr. Patric is a research forester and Mr. Evans a research hydrologist in the U.S. Forest Service Division of Forest Environment Research, Department of Agriculture, Washington, D.C. 20013.



Two-thirds of the nation's surface water issues from forested land.

Forestry, emerging as a scientific discipline at the turn of the century, ran headlong into the established profession of engineering with regard to trees and their effects on water supply. A spirited controversy developed. One school of thought (dominated by agriculturists and foresters) would rely upon properly used land to absorb precipitation where it fell, with gradual release from groundwater to insure abundant and regular streamflow. Foresters sometimes oversold this regulatory capability of proper land use in their zeal to achieve the proven advantages of forests to control soil erosion. An opposing school of thought (dominated by engineers) would rely upon instream structures to most advantageously regulate streamflow. From 1910 through 1920, the U.S. Army Corps of Engineers undertook empirical studies of the Ohio, Cumberland, Tennessee, Merrimack, and Wisconsin rivers to seek the possible influences forests might have on flow in large streams. Subsequent research has proved some of Corps Major Hiram Chittenden's conclusions remarkably accurate:

- Forests can mitigate freshet flows but have little effect on major floods.
- The prevention of forest regrowth, not the cutting of trees per se, can substantially accelerate the erosion of soil.
- Deforestation can increase streamflow.

Results of the several river studies supported Major Chittenden's conclusion concerning flooding as well as soil erosion, but only Corps Lieutenant Burr's study of the Merrimack River reinforced the major's last point: "Increase in forests since 1880 tends to show slight decrease in amounts of runoff but not enough to warrant a conclusion." In light of 20-20 hindsight, Chittenden's work often is cited as conceptually shrewd, but at the time it served little more than to fuel the land use versus structure controversy.

By the 1920s, people were looking to research for quantitative resolution of the streamflow controversy. Studies of the forest influence on water supply began slowly. Research in the eastern United States focused first on soil erosion in Mississippi and Wisconsin. Relief programs of the 1930s, the era of the Great Depression, provided major impetus to Forest Service research. Then the Coweeta Hydrologic Laboratory, in the mountains of western North Carolina, began studies of the forest influence on streamflow that continue to this day. Other Forest Service laboratories have been established at Oxford, Mississippi; Durham, New Hampshire; and Parsons, West Virginia. Several state universities (Georgia, Kentucky, Missouri, and Pennsylvania, for example) also conduct major research on water yield from forested land.

Water yield research usually features the unit watershed approach. Adjacent headwater catchments are selected for their similarity in physiography, soils, and vegetation. Precipitation is sampled in a network of rain gauges, and levels of streamflow through weirs are recorded on charts. Calibration is considered adequate when water yield from one of the watersheds (to be treated) is predictable at the 95 percent confidence level, based on water yield of the other (remaining untreated, or control) watershed. Some form of vegetation management, perhaps clear-cutting, is applied on the treated watershed. Predicted water yield, based upon measured flow from the control, is subtracted from measured water yield on the treated watershed. The difference—increased water yield—is accepted as the effect of vegetation management on streamflow. The unit watershed approach has produced much of our knowledge about the land phase of the hydrologic cycle on forested uplands, and about man's influences on it.

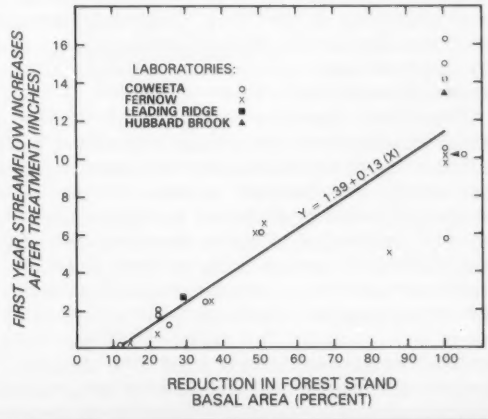
One of the long-term studies at Coweeta nicely demonstrates the results of research concerning forest cutting and its influence on the water supply. After a suitable period of calibration, all of the trees on watershed

Tree blowdown, illustrating vegetation loss from a natural catastrophe.

2430-hectare outdoor laboratory, Coweeta Basin, western North Carolina.

13 (16.1 hectares) were cut during 1939. Streamflow increased 362 millimeters, 65 percent greater than predicted flow. (A streamflow increase of 362 millimeters from a 16.1-hectare watershed may be envisioned more readily as 0.362 meters of rain falling on a 16,100-square-meter field or as 5,828 cubic meters of water.) In subsequent years flow gradually declined toward pre-cutting levels as the hardwood forest regrew. A 375-millimeter increase was realized when the clear-cutting treatment was repeated in 1962. Stormflow was unaffected by either treatment. Annual sediment production on the order of 300 kilograms per hectare, though insignificant by agricultural standards, was higher than observed after experimental clear-cutting elsewhere. This experiment is the only one to date that has been replicated in time.

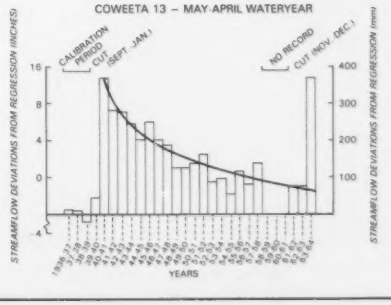
RELATIONSHIP BETWEEN STREAMFLOW INCREASE THE FIRST YEAR AFTER FOREST REMOVAL AND THE PERCENTAGE REDUCTION IN FOREST STAND.



Observations of increased streamflow after planned devegetation are by no means unique to experimental forest watersheds. Hay cutting and heavy grazing are known to cause smaller, more transitory increases. Added flows also have been observed following natural devegetation of forests in a non-research setting. The great New England hurricane of 1938 blew down vast expanses of forest, adding about 125 millimeters to the next year's flow of the Connecticut and Merrimack Rivers. No evidence of added flow persisted after 1941. Only 45 millimeters of added flow followed less extensive blowdown after a storm of 1951 on the watershed of New York's Sacandaga River. Severe defoliation by the gypsy moth in 1971 increased the flow of New Jersey's Pequannock River by about 135 millimeters. Runoff to a lake in Minnesota increased 120 millimeters following wildfire. Only 50 millimeters or so were added to stormflow after tree deadening and prescribed burning on several experimental watersheds in Mississippi, catchments so tiny that the streams flowed only during rainstorms.

Comparing flow data following experimental and na-

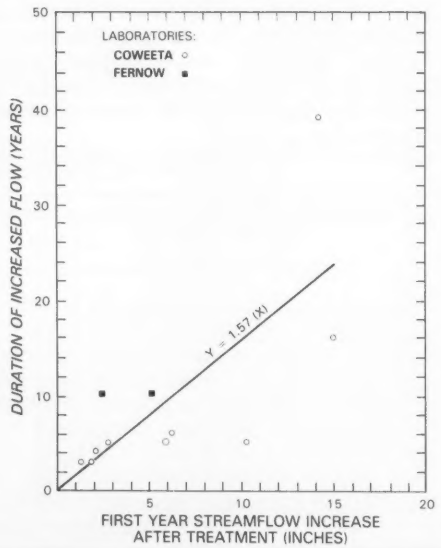
FLOW INCREASES DUE TO FOREST CUTTING, WATERSHED 13, COWEETA BASIN.



Trees re-establish naturally on abandoned farms in the east, but regrowth is gradual.

tural deforestation suggests larger flow increases in the research setting, and with good reason. Nearly complete loss of vegetation can be assured in planned studies, whereas partial loss is characteristic of blowdown, insect depradation, and forest fire. Less complete devegetation following natural catastrophe causes not only lesser increases of water yield but also more rapid return to pre-catastrophe streamflow because surviving trees as well as new growth rapidly reform the canopy. Results from two major laboratories suggest that few streamflow increases persist longer than 10 years.

RELATIONSHIP BETWEEN THE DURATION OF INCREASE IN STREAMFLOW AND THE FIRST-YEAR INCREASE IN FLOW AFTER FOREST REMOVAL.



There is ample reason for rapid revegetation, particularly in the eastern United States. Ordinarily, precipitation is abundant and regular, with this and related site factors favoring lush reforestation regardless of why original stands were destroyed. Not only do most hardwood species sprout vigorously, but natural seedling establishment on the order of many thousands per hectare is the rule. For example, five years after an experimental watershed in West Virginia was clear-cut, it was growing 22,000 stems per hectare of commercially useful species. Over 20,000 per hectare were counted two years after cutting a North Carolina watershed, a number decreased to about 7,000 when counted 10 years later. At tree maturity, perhaps 75 to 100 years after stand establishment, only 500 or 600 trees per hectare will have attained harvestable size. Comparable data are unavailable concerning tree regrowth after natural catastrophe, but seedling numbers surely are less because some of the larger trees always survive from original stands.

Reforestation (planting trees on abandoned land) reduced streamflow in New York, Ohio, and Tennessee. Reductions ranged from 76 to 172 millimeters per year, flow decreases commensurate with the increases following natural catastrophes.

Afforestation (natural re-establishment of trees on abandoned farmland) also reduces streamflow, but so gradual is regrowth that the flow decrease is virtually undetectable. For example, perhaps 80 percent of Massachusetts had been cleared for agriculture when record keeping on flow of the Merrimack River began in 1848. Farmland began reverting to forest at about the time of the Civil War, a reversion continuing a century later. Army Engineer Lieutenant Burr knew of this reversion and concluded that reforestation had slightly decreased streamflow. A few years ago, scientists at Harvard, armed with 60 more years of data and improved analytical techniques, could not improve on

Clear-cut areas minimize but do not eliminate evaporative losses. Even these small trees intercept precipitation and transpire soil moisture.

Burr's conclusion. They too found decreased flow on several branches of the Merrimack River statistically insignificant but apparently 35 millimeters less than average annual flow of the pre-Civil War era. This apparent reduction nevertheless represents a huge volume of runoff from watersheds many square kilometers in areal extent. The Harvard scientists suggested that dimished flow at this level could account for the decreased reliance on waterpower that has characterized New England's factory system since the turn of the century.

Watershed research shows why streamflows are changed by forest cutting. Consider this version of the familiar water balance equation:

P-ET = RO

P is annual precipitation.

ET (evapo-transpiration) is annual evaporative loss from forested land. It includes major losses to interception and transpiration as well as lesser losses to direct evaporation from the land surface and to physiological processes such as respiration and guttation.

RO is annual streamflow.

Given P as provided by nature, RO necessarily reflects ET. Disregarding the lesser evaporative losses, ET is primarily the interception and transpiration losses, readily influenced by stage of vegetative growth. On forest land of the eastern United States, ET has been demonstrated to range from perhaps 600 millimeters per year at southernmost latitudes to perhaps half that amount at the most northerly regions. This all-inclusive evaporative loss, incorporating roughly equal amounts of interception and transpiration, presupposes a complete canopy of tree foliage.

Even clear-cutting, however, cannot eliminate all interception, transpiration, and other evaporative losses. Hence, clear-cutting minimizes but does not eliminate ET, and substantially reduced evaporative losses account for the increased streamflow that follows. Partial forest cutting and natural catastrophe reduce evaporative losses to some lesser extent yet still increase streamflow in rough proportion to the reduction of forest canopy. Redevelopment of a complete leafy canopy, requiring surprisingly few years, marks the return of evaporative loss—and hence streamflow—to pre-cutting levels. Because conifers are leaf-covered year round and have at least twice the leaf surface area of hardwoods, interception losses are demonstrably greater from coniferous stands. Transpiration loss substantially larger from conifers than from hardwoods has yet to be demonstrated, although the potential for greater transpiration from coniferous vegetation seems to exist.

Another study at the Coweeta Hydrologic Laboratory

This clear cut produced the largest streamflow increases ever measured in the eastern United States.

Aerial application of a selective herbicide replaced trees with grass on this municipal watershed.

Hand-cutting weed and brush revegetation annually on Coweeta watershed 17 maintained water yield increases through reduced evapo-transpiration.

demonstrated the effect on streamflow of reforesting with a coniferous stand. The mature hardwood vegetation on watershed 17 (13.4 hectares) was clear-cut in 1941, increasing annual water yield 408 millimeters above predicted levels. Vigorous weed and brush revegetation was cut back manually almost every year through 1958. During those years, streamflow increases leveled off to about 250 millimeters more than predicted flows. Watershed 17, planted with white pine seedlings in 1957, was sprayed with selected herbicides so that the seedlings could survive competition from the more vigorous hardwoods. Again streamflow began to diminish as the pines grew. By 1967, measured streamflow was equal to predicted flow. By 1970 there was a complete pine canopy, and even today streamflow from watershed 17 remains well below pre-1941 levels. Sediment production averages a mere 85 kilograms per hectare per year from this watershed, and none of these treatments has affected stormflow.

A recent review of worldwide experience, no less than 92 unit watershed studies, permits these generalizations concerning the influence of forest cutting on water supplies:

- Reduction of forest vegetation increases water yields. Cutting coniferous and hardwood forest stands increases annual water yield about 40 and 25 millimeters, respectively, per 10 percent reduction of forest vegetation.
- Reductions of forest vegetation of less than 20 percent do not measurably increase water yields.
- Establishment of forest cover on sparsely vegetated land decreases water yield.

These generalizations incorporate much variability among watersheds and treatments as well as unavoidable differences in soils, climate, physiography, and vegetation. The original reports must be consulted to appreciate the range of conditions and results that lead to these simple summary statements.

We have traced an evolution of thinking concerning the forest as a supplier of water with which few people are familiar. Most people cling to the hoary notion that "streams diminish as the woodlands are cut away," and for good reason. Claims to that effect are common in current popular literature and schoolbooks. Even the presumably authoritative writing can be confusing. Consider these statements by a modern writer on international forestry: "They [forests] lend stability to hydrological systems, reducing the severity of floods and permitting the recharge of springs, streams, and underground waters. . . . Decades of research have proved that deforestation can increase the severity of flooding, reduce streamflows and lead to the dessication of springs during dry seasons, and increase the load of sediment entering waterways."

The first of these statements does not bear critical scrutiny. "Lend stability to hydrologic systems" sounds comfortable, but vigorous brush or grass vegetation provides fully as much stability as forests. Exceptionally heavy rains are followed by severe floods, regardless of forest conditions. Forests cannot permit "the recharge of springs, streams, and underground water," although they can influence the distribution of precipitation to those sources of water. Understanding that influence is what watershed management research is all about. The second statement ignores the real thrust of watershed research. There have been no decades of research to prove the hydrologic effects of deforestation. None were needed. The effects of deforestation were known long before research began on how forests influence water yield.

To add to the confusion, forest cutting that necessarily accompanies the harvest of wood to meet human needs becomes entangled with deforestation and its effects on water. Deforestation starts with tree cutting, but to cause damage it must be followed by neglect: repeated burning, exploitive farming, or over-grazing.

Eroded, gullied land—caused by deforestation and subsequent poor land management.

Cable transport of logs harvested from steep slopes minimizes road networks, log skid trails, and soil erosion.

Only gross mismanagement of this sort can preclude the reestablishment of trees. Deforestation does lead to hydrologic ill consequences, but exploitive deforestation differs dramatically from custodial use of forest land for the continuing production of many goods and services. Foresters continue to find ways to harvest wood without disrupting the cherished value of trees as the premier protecter of soil from erosion. Furthermore, most measures to best protect the soil are the best measures to protect forest streams. Prudently managed forests maintain water values about as well as undisturbed forests, and judicious forest cutting has the potential to increase water supplies.

That potential, however, is unlikely to be realized in the eastern United States, where precipitation is generally abundant and most water supplies are adequate except during occasional periods of relative drought. Also, most (about 85 percent) of the 456 million hectares of eastern forest land are owned in small tracts by myriad private owners. When one owner harvests timber on his tract, trees are regrowing after cutting on another tract, so flow increase in one place is nullified by decrease elsewhere. Thus, flow in the larger streams that integrate water production from many small tracts is uninfluenced by cutting. An urgent need for water could conceivably result in synchronous cutting to increase streamflow. However, under present conditions it seems economically unattractive, even impractical. Managing forests to increase water yields is improbable during normal weather and impossible during abnormally dry weather. No amount of cutting can extract water from lands so dried by evaporation that no streamflow is possible. Environmental concern, too, precludes synchronous cutting.

Nevertheless, some options do remain open for increasing water yield from tree-covered land. Forested watersheds fully controlled by municipalities can be maintained in grass or other less water-demanding vegetation for trees. Low-growing plants evaporate less water and fully protect the soil from erosion. Experience with the Merrimack River even suggests the desirability of eliminating trees from the landscape as a means to augment water supplies. Frequent harvest of the entire forest biomass ("wood silage") is another possibility. Municipalities concerned with water shortage should avoid the conventional practice of planting conifers around reservoirs, a practice that probably costs them water. It has even been suggested that planting 12 million hectares to pine, as foreseen in the southern United States, could troublesomely reduce that region's water supply.

Research amply demonstrates that tree cutting can substantially increase water yield from forested land with only slightly increased sediment production. However, abundant precipitation ordinarily provides water sufficient to meet most human needs, so large-scale vegetative treatment to increase regional streamflow is unlikely to be tried in the humid east. Nevertheless, vegetative treatment could be a valuable option for augmenting water supplies to help meet critical local needs. ■

Large-scale vegetative treatment to increase regional streamflow in the humid east appears unlikely.

BALTIMORE HARBOR TUNNEL:

MAINTAINING WATER QUALITY

by William Siefring and William L. Hart

The Fort McHenry Tunnel across Baltimore Harbor for Maryland Interstate 95 is the largest single construction project in the history of the country's interstate highway system.

Because of local citizens' outcry about the historic significance of Fort McHenry, original plans in 1970 to build a bridge almost directly over the fort were scrapped. Scene of "the rocket's red glare," the fort inspired Francis Scott Key to write "The Star Spangled Banner" in 1814 when the garrison held firm against bombardment from the British fleet. To preserve the scenic setting of the fort, the Interstate Division of Baltimore City (IDBC) designed an 8800-foot tunnel for eight lanes of traffic to cut across the harbor and bend around the tip of the peninsula where Ft. McHenry is located.

The underwater portion of the tunnel is 5400 feet and will be constructed with 16 pairs of prefabricated steel-shelled concrete tubes, or elements. Each pair of tubes will be placed side by side, 10 feet apart, in a trench being dredged across the inner harbor. Each tunnel element has two bores, and each bore can carry two lanes of traffic for a total of eight lanes, four in each direction.

The tunnel elements are 350 feet long, 82½ feet wide, and 42 feet high. When the concrete lining is cast, each element will weigh approximately 35,000 tons. Elements will be prefabricated, towed into position, sunk, and connected with special seals. Because the elements are being placed in pairs, this tunnel will be the widest concrete submerged tube tunnel in the world.

Although the tunnel solved the problem of historical preservation, it created new problems that had to be resolved before construction could begin. A central concern was the dredging itself. An estimated three and a half million cubic yards of material had to be removed to create the 179-foot-wide trench across the harbor and to descend as deep as 115 feet to go below the 42-foot-deep navigation channel near the eastern shore. This amount of material would fill a train of boxcars 300 miles long.

Dredging has been important economically and environmentally to the United States almost since the founding of this country—important in improving and maintaining navigable waterways, cleaning up rivers, controlling floods,

Mr. Siefring is an account management manager and Mr. Hart is polymer product manager for Calgon Corporation's Water Management Division, Pittsburgh, Pennsylvania 15230. Mr. Siefring was Calgon's technical representative for the Fort McHenry project; Mr. Hart was instrumental in developing the treatment technology for dredging effluent.

restoring beaches. Dredged material often was dumped in open waters, but the late sixties and early seventies saw many new environmental laws passed that related to clean water and included dredging activities.

One reason for this increasing water legislation was a realization that water resources, like energy, are finite and must be protected and preserved. Baltimore Harbor is part of the famous Chesapeake Bay region, one of the east coast's richest fishing and recreation areas, as well as an important seaport.

Some of the reasons that open dumping of dredged materials is restricted are increased turbidity of water from the sediment, burying bottom dwelling organisms, and possible release or resuspension of industrial contamination from the upper layer of material during dredging and disposal.

One estimate of the quality of dredged material in the Baltimore area is that half the proposed dredging for the next 20 years is not deemed suitable for overboard or open water disposal. An increasingly common solution for environmentally acceptable dredging disposal is the use of containment areas. The growth in recent years of confined disposal is the result of concern over suspected pollutants in dredged material, especially in the upper layers of "muck" which contain everything from chemicals to sewage sludge, wood, rocks, metal, and other debris.

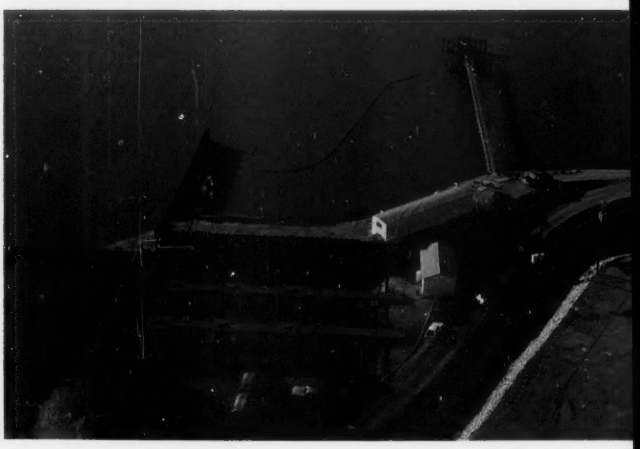
Because the harbor is a heavily industrialized area and carries a great deal of shipping traffic, its bottom sediments were analyzed. The Interstate Division commissioned a year-long environmental study in anticipation that a public hearing and an environmental impact statement would be required before dredging for the tunnel could begin. During the time of the hearing, the division applied to the Corps of Engineers for a dredge and fill permit and received the permit six months later, during the spring of 1980.

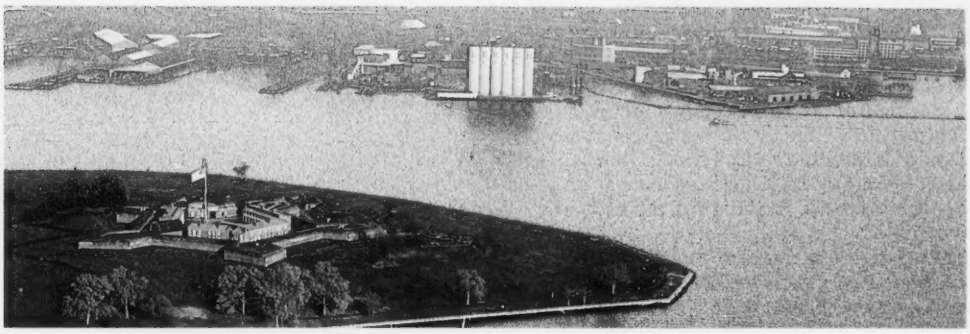
Because preliminary investigations showed a number of chemicals and organic compounds, a confined disposal site costing several million dollars was built to protect the harbor waters. The cost of a 146-acre containment area near the dredging project was originally estimated at $47 million, but because the Interstate Division wanted to be able to use the land for a port terminal, additional construction was required. That construction included 76 cellular cofferdams made of steel plate and filled with sand. The 62-foot diameter cells form a perimeter more than a mile long around the containment area. Land dikes are lined with clay to prevent any water seepage.

Because the upper 10 feet of sediment in the harbor bottom was thought to be contaminated, the containment was divided into two areas, with a smaller area to hold the upper "black mayonnaise-like" sediment, which will take a long time to consolidate. This area will not be used for a terminal but will be planted with marsh grasses to stabilize the fine-grained sediment and aid in consolidating the area.

The remainder of the dredged material contains sand and clay and will be more suitable for reclamation. Because the material is more liquid than solids, time is required for the

At lower right, a tunnel element is being prepared for sinking into place. It will be near the western end of the tunnel, which comes up beside Fort McHenry (left center) and stretches across to the east side of the harbor, beside the concrete towers in the distance.
(Photos by Dick Brehl, of Associated Photographers, Pittsburgh.)





To preserve the historical environment of Fort McHenry, a tunnel is being constructed across the bottom of Baltimore Harbor, instead of a bridge, as the final link in Interstate 95. The largest single construction project in the history of the interstate highway system, the tunnel will be the widest submerged concrete tube tunnel in the world.

Several tunnel elements are floating in the harbor, waiting to be towed into position and covered with concrete. Each element contains two bores, and each bore carries two lanes of traffic. Eight lanes of traffic will travel through the tunnel, four in each direction.

The main containment area (upper half) with weir structure in the center of the water. Lower portion is the settling basin with a grid over the end where mixers aid in flocculation. Polymers are added from a tank inside the small white building through a pipe out to the weir, and also at the head of the settling basin, where dredging effluent first enters.

solids to settle from the carrier water, and the amount of time is directly related to particle size; the finer the particle, the longer the time required for settling.

Obviously, a natural settling process would take too long, and the problem is complicated because dredged materials are so varied, ranging from large rocks down to fine colloidal particles. The problem faced by the dredging contractor, Great Lakes Dredge & Dock Co. of Oak Brook, Illinois, was made even more difficult because the containment area is about half the size ordinarily required for the amount of material being dredged.

The first step in protecting harbor water quality was to use a hydraulic cutter suction dredge, which pumps all dredged material through a pipeline into the containment area. Great Lakes is using its hydraulic dredge, the *Illinois,* flagship of the largest private fleet flying the U.S. flag. Because material is sucked into the pipeline as it is removed, there is no widespread resuspension of sediment.

Before dredging started, an independent laboratory, Ecological Analysts of Sparks, Maryland, analyzed samples of harbor water using gas chromatography, atomic absorption, and standard wet chemistry analyses. During dredging, regular samples are taken in several locations: at the dredge, in the containment area, and at the outfall of the settling basin, a 100-by-1100-foot basin constructed between the two containment areas where final clarification of dredging effluent takes place.

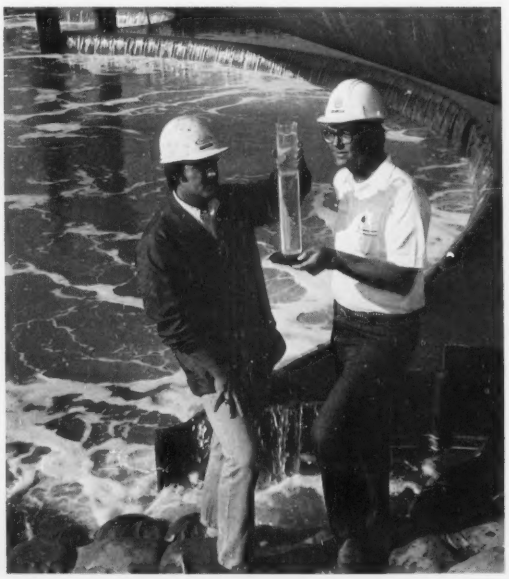
Extraordinary measures were required to enable the dredging contractor to meet strict environmental standards. Water discharge from the containment areas had to be the same quality as normal harbor water, with no more than 400 parts per million of suspended solids.

Most of the solids settle out in the containment areas where a height-adjustable weir in each area controls water level. The weirs are watertight rectangular vaults constructed around the entrance to large pipes that carry effluent into the settling basin. Boards are added around the top as the water level rises. As more and more solids from dredging fill the area, the weir has to be built higher to keep the dredged material covered by water, to allow settling time and to prevent solids from being stirred up again and carried over into the settling basin.

To reduce the solids concentration remaining in the effluent from the containment area down to the required level, Great Lakes is adding polymer-based flocculating agents from Calgon Corporation. These agents are a class of synthetic, organic, water-soluble polyelectrolytes that have gained wide acceptance in numerous solids-liquid separation processes.

Polymers are formed of very long submicroscopic molecular chains. Each chain has thousands of ionically charged sites which neutralize charges of suspended particles. Polymers may be cationic (positively charged), anionic (negatively charged), or nonionic (neutrally charged). Performance of polymers depends upon their degree of ionization or charge density and molecular weight and the proper-

William Siefring (left), Calgon technical representative, and Martin Snow, Great Lakes project manager, examine a cylinder of clear water just filled from the outfall of the settling basin where it discharges into Baltimore Harbor. This illustrates the effectiveness of the polymer treatment in removing suspended solids. Great Lakes is required to return water with no more than 400 parts per million suspended solids to the harbor. Readings are made by an independent laboratory contracted to monitor the effluent. Analyses often show levels of less than 100 parts per million in the discharge.

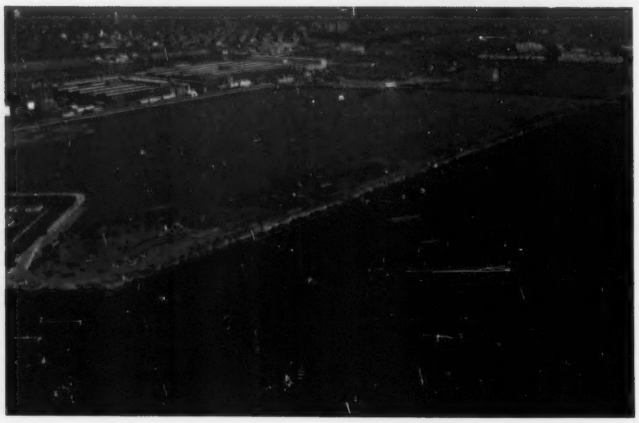


Because the tunnel will be so wide, a trench 179 feet wide at the bottom has to be dredged nearly 6000 feet across the harbor, with sloping sides to prevent their sloughing off. More than three and a half million cubic yards of material are being moved by Great Lakes Dredge & Dock Co. of Oak Brook, Illinois. This material would fill a train of boxcars 300 miles long, and will fill the 110-acre containment site to a height of 20 feet.

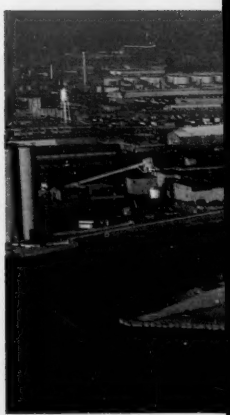
Volumes of 50 to 80 million gallons per day of muddy water and rocks spew from this 27-inch pipeline into the containment area, traveling as much as two miles from where the dredge is removing material from the harbor bottom.

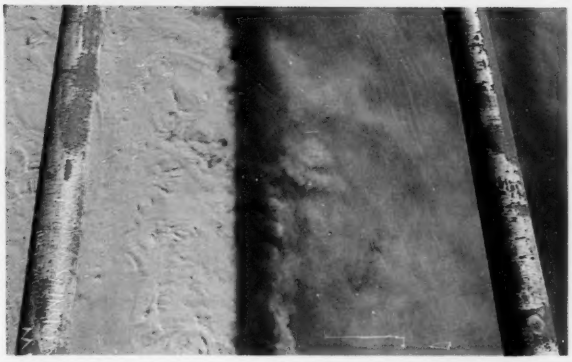
BALTIMORE HARBOR TUNNEL

Polymer technology is helping Great Lakes meet clean water standards. Dredging effluent is treated so that solids settle out in this basin, and only clean water returns to the harbor. The dramatic contrast between dredged effluent (left) and the water returning to the harbor (bottom) demonstrates the effectiveness of the polymer treatment system.



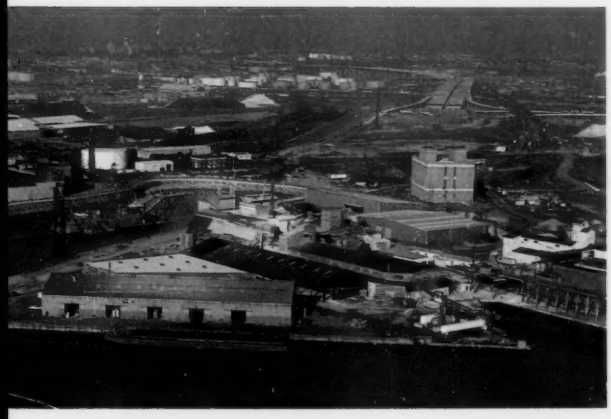
Moving such an enormous amount of sediment and spoils from the harbor bottom created concerns that the harbor might be muddied. Stringent requirements were placed on the operation, including the construction of multimillion dollar containment areas and a treatment and settling basin. Cellular steel cofferdams filled with sand enclose the containment area, which eventually will be completely backfilled. The smaller area will be a wetland covered with marsh grass, and the other area of more than 100 acres will be completely reclaimed and made into a terminal.





Looking down into the beginning of the settling basin, where treated effluent enters from the containment area, muddy discharge at left is bordered by clear water, with sludge "blanket" of already flocculated solids visible a few feet beneath the surface. This is a classic example of water clarification, looking almost like an upflow clarifier, where raw muddy water dosed with polymers begins to drop solids to the bottom and clear water rises.

The Illinois, *flagship of the largest private dredging fleet flying the U.S. flag, is at work on the eastern end of the tunnel near Lazaretto Point. A 27-inch discharge on this hydraulic dredge, with 10,000 installed horsepower and an effective dredging depth of nearly 100 feet, makes her one of the most productive dredges in the world.*



ties of the particles to be removed. In addition to charged sites, polymers also contain hydrogen bonding sites that can act as bridges between suspended particles. Particles rapidly become attached to the polymer chain in the flocculation process. The solids-liquid separation actually involves two stages: coagulation and flocculation. Coagulation consists of charge neutralization and microfloc formation; flocculation consists of physical agglomeration of the microfloc and entrapment of suspended solids.

Particles that would require months to settle without treatment are settled in minutes by small doses of polymers, measured in parts per million. Before the polymers were selected for use at Baltimore Harbor, a series of laboratory jar tests examined the performance of different polymers by determining settling characteristics of the different types of dredged material encountered in the project. Treatment dosage was developed based upon settling characteristics as determined in the tests.

In general practice, and in the harbor dredging, two or more classes of suspended solids are encountered, and prescribed treatment often involves combined treatments of polymers. For instance, a dredged discharge will probably contain colloidal clays and solids of many diameters. The finer colloidal materials usually have a negative charge and are destabilized with a cationic polymer, followed by treatment of the concentrated slurry with another polymer to increase size of the agglomerated particles and provide rapid settling.

The first polymer is introduced at the weir, where turbulent flow at the entrance to pipes going into the settling basin provides good mixing. Mechanical mixers within the settling basin also aid the settling process. Clarified water is discharged back into the bay at the end of the basin. Water is continuously monitored to insure that standards are being met.

Within the settling basin, Great Lakes also has installed an innovative system that will continuously remove solids from the bottom of the basin. Consisting of rows of perforated pipes and pumps, the apparatus slowly "sweeps" up and down the length of the bottom of the basin and pumps the solids over to a disposal area. The 110-acre area eventually will be completely backfilled and reclaimed. This procedure will enable Great Lakes to dredge continuously rather than dredge for two shifts and spend the third shift pumping out the basin.

While this particular dredging project is using a pipeline dredge, polymers also have been evaluated in hopper dredging operations in a major port. This information may be applicable to some additional harbor dredging projects, such as Hart and Miller Island confined disposal area or ship channel deepening projects.

Considering that the dredging projects just for Baltimore Harbor over the next 20 years are estimated at more than 120 million cubic yards, with much of the material requiring containment, polymer applications may become more widespread. ■

short take

the selling of waste

by William J. Marrazzo

"Gardenlife," Philadelphia's sludge product marketed as a soil conditioner.

(Photos courtesy of the City of Philadelphia.)

The City of Philadephia is putting to constructive use a by-product of its wastewater treatment that once posed an environmental problem along the Atlantic coast.

The product is sludge, and at one time the disposal of this unwanted substance embroiled the city, the State of Pennsylvania, the U.S. Environmental Protection Agency and several other organizations in protracted litigation.

Thanks to research and some creative technology, the product is now not only being used to help transform abandoned strip mines into grazing lands, but it also helps keep Philadelphia baseball parks and golf courses green and is even earning revenues marketed as a soil conditioner called "Gardenlife." To date, the city has sold an estimated quarter million 40-pound bags of what it used to haul, in cruder from, in barges out to sea where it was dumped east of coastal beaches.

The story of the waste conversion program began in 1971 when Congress passed the Marine Protection, Research, and Sanctuaries Act, aimed at controlling ocean dumping. Under its authority, EPA required Philadelphia to move its sludge dump site 36 miles farther out into the Atlantic as an interim measure while the city developed an alternative and more hygienic method of sludge disposal.

EPA further required Philadelphia under the permit system to reduce the quantity of barged sludge for ocean dumping by 50 percent before 1979, and totally stop ocean dumping by December 31, 1980.

After a number of lawsuits involving many parties, agreement was reached on May 30, 1979, when they signed a consent decree incorporating three major provisions. First, the decree called for specific construction dates for upgrading each of the three city-operated wastewater treatment plants. The construction schedule is designed to ensure that by November 1983, 86 to 89 percent of the biochemical oxygen demand (BOD) that the three plants discharge into the Delaware River will be removed. (Biochemical oxygen demand refers to the oxygen required to decompose organic matter in water.)

To accomplish the cleanup, the secondary treatment systems of the three plants will increase their capacities to 250 million gallons per day (mgd) at the Northeast Plant, 210 mgd at the Southwest Plant, and 140 mgd at the Southeast Plant.

A second part of the decree called for the city to reaffirm its commitment to stop its ocean dumping of sludge by December 31, 1980 (*EPA Journal*, January 1981). Third, the agreement provided for the creation of a fund with a deposit of $2,165 million, to be used to undertake environmentally beneficial projects not currently required by law. One such program that the city has initiated is a monitoring program for metals and toxic chemicals entering the city's water treatment plants and being discharged from wastewater treatment plants. This program is funded for $165,000. The other existing program is a $2 million project to upgrade Philadelphia's combined sewer overflow control system.

SLUDGE CHARACTERISTICS

Philadelphia presently generates 190 dry tons of sludge per day (70,000 per year) and the projected sludge load for 1985 is 305 tons per day (111,300 per year). In comparison to that of other large cities, Philadelphia sludge is rich in organic nutrients and low in contaminants—averaging 20 parts per million (ppm) cadmium, less than 2 ppm polychlorinated biphenlys (PCB's), and 600 ppm lead.

The Philadelphia authorities examined a series of alternatives to ocean dumping of its sludge, particularly thermal processing, land disposal, and land utilization. One form of thermal processing that the city chose is known as the "Ecorock" process, where dewatered sludge and municipal solid waste incinerator residue is combined in a rotary kiln. The inert material in the wastes will reach a molten state at 981°C (1,800°F) that, when cooled, becomes a hard rock. When crushed, the rock is expected to be a high quality road aggregate that will pass Federal Highway Administration

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Mr. Marrazzo is water commissioner for Philadelphia. This article is reprinted from the September-October 1981 issue of *EPA Journal*.

tests for paving materials. A demonstration plant for the project is being completed.

Land disposal of sludge was not a viable alternative, because the Pennsylvania Department of Environmental Resources does not recommend mixing wastewater sludge with municipal refuse in landfills. Using sludge to help improve land, on the other hand, presented the most economically feasible alternative. The Philadelphia authorities were particularly interested in using the sludge to recover stripmined areas of the state.

After examining the alternatives, Philadelphia formulated the Sludge Master Plan, which incorporated a number of programs.

PRODUCING A HIGH-QUALITY PRODUCT

The sludge must be as free of toxics as possible. One way in which Philadelphia maintains a consistently high quality sludge is through its industrial waste regulations. Starting in 1977 and before EPA promulgated industrial effluent limitations for metals, the city implemented its own set of metals effluent limitations for industrial contributors to the city's treatment facilities. These limitations significantly lowered the metals concentrations of the city's sludge.

Philadelphia's sludge is further improved by anaerobic digestion for at least 15 days at 37°C (98°F), which serves to significantly reduce pathogens and odors. The digested product (5% solids) can then be utilized in one of the alternative plans—the Liquid "Philorganic" Program. Containing up to 50% organic matter with 3 to 4% nitrogen by weight, the liquid digested sludge can be sprayed or injected on grain or sod farms.

Dewatering also enhances the use of other alternatives in managing sludge.

After dewatering, the sludge is loaded on dump trucks and transported to interim composting sites at each plant. The Philadelphia authorities use the extended pile aeration method, where woodchips are used as a bulking agent in a 2 to 1 ratio of woodchips to sludge. Because woodchips are a major expense at over $8 per cubic yard, a shredder and screen system is used to reclaim them. Moreover, the screened compost is a fine, homogeneous soil conditioner

PHILADELPHIA WATER DEPARTMENT
SLUDGE MANAGEMENT PROGRAMS

PROCESSING	UTILIZATION	DEVELOPMENTAL
Dewatering	Liquid Application	Recycle Centers
Composting	Strip Mine Reclamation	Eco Rock
Shredding/ Screening	Bulk Give Away	
Storage	Small User Give Away	
	Marketing	

that is marketed under the name "Gardenlife" as a soil conditioner and may be purchased in 40-pound or bulk quantities. The screening process greatly increases the desirability of the product, and the city therefore plans to expand the screening facilities, presently rated at 200 cubic yards per day.

The marketing program sold more than 250,000 bags of "Gardenlife" by July of 1981. This may eventually phase out a current give-away program, but both will continue until marketing proves successful.

Sludge not screened and sold is given away as part of the Philorganic program. The city provides a series of brochures at distribution centers that explain how the compost can and should be used by consumers. No EPA regulations or guidelines cover the distribution and marketing of Philorganic, although the Philadelphia Water Department has adopted a conservative policy, one condition of which recommends that Philorganic not be used on vegetables. The program's popularity is on the increase. Between July and December of 1980, 2,600 dry tons of Philorganic were given away.

Dry and liquid Philorganic has also been used in several special projects. Ball parks, parks, and city-owned golf courses have benefited from Philorganic, as have several reclaimed landfills and abandoned lots.

Sludge application in stripmine reclamation.

RECLAIMING STRIP MINES

Philadelphia's plan to use sludge to reclaim strip mines stemmed from a demonstration project conducted in 1978 on 10 acres of land in Somerset Country in southwestern Pennsylvania. One part unscreened compost and one part dewatered digested sludge, called a "mine mix," are added to loosened soil that has previously been recontoured and limed to immobilize heavy metals. Present guidelines allow a maximum application rate of 60 dry tons per acre. For each reclamation project, a permit application is prepared and submitted to the Pennsylvania Department of Environmental Resources, with copies also sent to township supervisors and local health officials for review. Once a permit is approved, local truckers are hired to transport the sludge. Usually, these are coal trucks delivering coal to the Philadelphia area that can transport the mine mix back to western Pennsylvania on the return trip.

Before the sludge is applied to the land, erosion and drainage control measures must be carried out and the site preparations approved by inspectors. For the application, 2-acre plots are staked out, and at the 60 dry tons per acre loading rate, 10 truckloads of mine mix are added to the limed soil. Finally, a seed mixture of two legumes and two grasses is spread at a rate of 60 lb. per acre. The site will then be monitored for two years to guard against contamination by metals. The goal is to make the land suitable for grazing.

The city presently is using 60 to 70 percent of its sludge in the stripmine reclamation program. The cost of the program is about $200 per dry ton, making it one of the city's most economically feasible alternatives to ocean dumping. ■

PERCEIVING FLOOD RISK

by James T. Lorelli

The decision by Americans to reside on floodplains despite the ever present danger of property damage and potential loss of life contributes to disaster losses expected to exceed $2 billion annually with increases projected by the Office of Emergency Preparedness to reach $5 billion by the year 2020. Reasons for this preferred residential pattern are both varied and complex. Natural hazard investigations demonstrate that in many extreme geophysical environments hazard perception levels are influenced significantly by both recency and magnitude of past experience.

The consequences of repeated flooding likewise alter hazard perception and influence the adjustment strategies employed by individuals to cope with that threat. One of the more salient means of homeowner protection today is the purchase of national flood insurance, made available through a program designed to bring about a more comprehensive management of the nation's flood-prone areas. While flood frequency tends to heighten the sale of insurance policies, it simultaneously fosters a serious consideration of voluntary relocation from the floodplain. The study of Selinsgrove, Pennsylvania, shows in microcosm the interactions and linkages between these two forms of adjustment and proposes fundamental changes in the flood insurance program that would result in enhanced opportunities for homeowners to reconsider their future commitment to reside on the floodplain.

Dr. Lorelli is an associate professor in the Department of Geography and Earth Science at Bloomsburg State College, Bloomsburg, Pennsylvania 17815.

The Susquehanna River is the major flooding source for Selinsgrove and other Pennsylvania communities. Almost 65 percent of the state's flood-prone land is in this basin. (Photos by the author.)

STUDY PURPOSE AND METHODOLOGY

Selinsgrove, Pennsylvania, typical of many structurally unprotected communities within the Susquehanna River Basin, experienced its greatest flood of record from tropical storm Agnes in June 1972. A subsequent extensive field survey of floodplain homeowners gathered data on flood experience, hazard perception, knowledge of flood insurance, and commitment to the floodplain. Other dimensions such as value orientation, internal-external control, and socioeconomic background were also canvassed.

In 1975, another flood hit many unprotected central Pennsylvania communities, including Selinsgrove. This flood (Eloise), although less serious than Agnes, constituted the second traumatic experience within a three-year period. How did this flood change perception of the hazard? Was the range of adjustments adopted to cope with the recurrent flood threat altered? What is the present feeling about living on the floodplain? The existence of a computer data bank based on over 80 personal interviews provided not only a substantial amount of information used directly in this study but also made possible the administration of a second, more specific, questionnaire relating only to the last flood episode. Changes in hazard perception and adjustments adopted could be compared by this methodology, and insight gained in terms of how certain specific adjustments are linked as well as the direction of change as a consequence of this linkage. An audit of the most recent Selinsgrove flood provides the basis for recommending changes in Federal floodplain management policy guided by the direct experience of individuals at risk.

Property was rehabilitated rapidly in many Pennsylvania communities after disastrous flooding. To the unknowing, this tranquil scene masks the serious potential for destructive future floods.

Vacation cottages along the Susquehanna were often initially constructed on elevated blocks or other supports to minimize damage from spring floods.

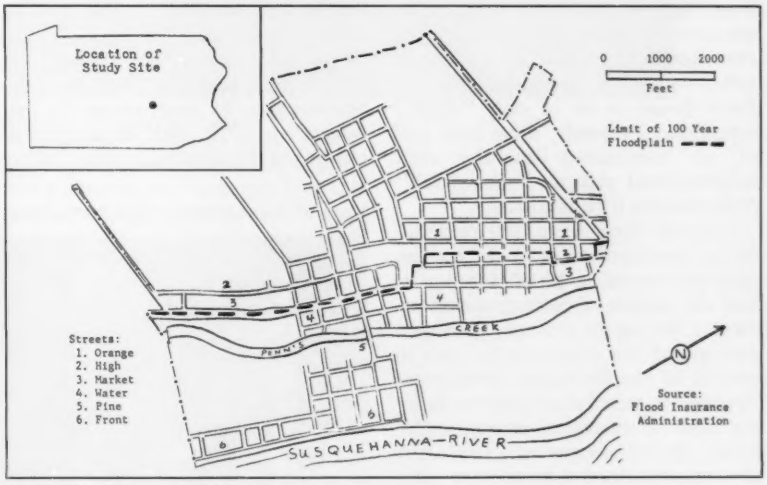
THE STUDY SITE

Two sources of floodwater exist within Selinsgrove's corporate limits of 1.8 square miles. The West Branch of the Susquehanna River rises on the Appalachian Plateau and flows eastward to Williamsport. From this point the river turns sharply southward and merges with the North Branch at Sunbury. The main stem flows southward from this junction past Selinsgrove, eventually discharging into Chesapeake Bay. The second watercourse, Penn's Creek, begins 50 miles west of State College. Draining a region of 554 square miles, it enters Selinsgrove at the northern borough line and flows through the town nearly parallel to the Susquehanna River. That section of Selinsgrove positioned between the river and Penn's Creek is known locally as the Isle of Que.

Floods on the Susquehanna occur in spring and summer. The former are associated with heavy rainfall and snow melt, the latter with long-duration precipitation. The dates of major Susquehanna River flooding at Selinsgrove are September 1975, June 1972, March 1964, May 1946, March 1936, and September 1934. According to Geological Survey studies, the main cause of flooding is the Susquehanna River backwater; Penn's Creek is secondary.

The area inundated by Agnes contained an estimated $4 million of residential, business, and industrial investment. Actual flood damage was placed at $1.6 million for homes and over $1 million for industrial and commercial properties. Official damage statistics before 1972 were not kept. In September 1975, a 60-year flood forced residents from the threatened Isle of Que area. Damage figures to public and private facilities were estimated to be one-quarter the level attributed to Agnes.

Streams such as Penn's Creek are subject to flash flooding and contribute significantly to making Pennsylvania the leading state in flood-related losses. Average annual flood loss for the past decade has exceeded $300 million.



Map of Selinsgrove, Pennsylvania.

Contained within Selinsgrove's 100-year floodplain is about 40 percent of the borough's total corporate area. Of the estimated 736 owner-occupied, one-family dwellings, less than 20 percent are on the floodplain. After the 1972 flood, $53,000 was spent for channel improvements on two unnamed tributaries within the borough. Work centered on cleaning debris that had accumulated from earlier high water.

RESEARCH FINDINGS

Data analysis suggests several findings to be significant in explaining how recurrent floods influence hazard perception and the manner in which people adjust to the situation.

PERCEPTION OF THE NEIGHBORHOOD FLOOD THREAT

The manner in which homeowners describe the threat from flooding to their neighborhood has been altered by the Eloise experience. The percentage of respondents believing the neighborhood flood threat to be "severe" has decreased from 46 percent to 38 percent. Similarly, there was a 12 percent reduction among persons believing the flood threat to be of only "slight" magnitude. Presently, more than half of all respondents appraise their neighborhood risk as "substantial." None believes it "nonexistent."

Tropical storm Agnes was responsible for combined property and content damages exceeding $5000 for almost half the sample of Selinsgrove homeowners. Eloise, in contrast, generated damages of that magnitude for only 10 percent of the floodplain population. Among two out of three persons claiming either no damage or damage under $1000, the Eloise experience reinforced the idea that flood risks are ever present and their neighborhoods are perceived as having more than just a "slight" problem.

FUTURE VULNERABILITY

The personal vulnerability perception of hazard was assessed by the question, "If a flood is to come again, do you think it would damage your home severely, substantially, slightly, or not at all? " Changes in the direction of this component are similar to those about the neighborhood flood threat. If a flood were to come again, fewer people today (28.9 percent versus 40 percent) believe the damage to them will be "severe." Those persons believing future damage to be "slight" have decreased from 28 percent to under 15 percent. In fact, after Agnes, about six percent of those interviewed felt personally invulnerable to future flood damage. The attempt to deny or denigrate the possibility of future personal loss has been described by natural hazard researchers to be one mechanism for coping with uncertainty in a high-risk environment. There were no homeowners, by comparison, in that category in 1978. Half of all persons residing in the floodplain today believe personal damage to be "substantial." This is double the number following the Agnes flood. Further, the difference in flooding magnitude between Agnes and Eloise has instilled a marked uncertainty about future damage among six percent of the residents compared to zero percent in 1974.

Hydrologically there exists about a one percent chance each year for widespread community flooding. People experiencing two low-level probabilities in rapid succession are expected to perceive the hazard to them far more seriously than are others. Although the feelings of future damage for all residents are believed to be transitory, it is speculative to assess how long the changes will last and in what directions they will be altered given the absence of this hazard.

Many of Selinsgrove's oldest homesteads enjoy waterfront scenery.

FLOOD INSURANCE

Enactment of the 1968 National Flood Insurance Program represented an attempt to stem the rising cost of flood control and disaster assistance by providing homeowners with the opportunity to insure themselves voluntarily against the impact of floods. Selinsgrove entered the national program on July 30, 1971, before Agnes, but no insurance policies were in force before that catastrophe. The absence of structural floodplain protection for this community did not provide an early incentive for insurance adoption. Examination of insurance sales elsewhere revealed a similar response pattern of purchases remaining neglible in the absence of recent flooding. At the time Agnes struck Pennsylvania, only 683 policies had been sold, including two in Wilkes-Barre and none in Harrisburg, the state capitol.

Despite the high flood risk, residents who have lived in the waterfront area for much of their lives feel a deep sense of attachment to home and neighborhood.

A riverfront location offers many environmental amenities which have made this section of Selinsgrove residentially desirable.

In 1974, just two years after Agnes devastated Selinsgrove, approximately half of all floodplain residents were insured. Homeowner adoption of flood insurance was influenced by a combination of factors. For example, the adoption pattern showed that as dollar damage increased so did the percentage of adopters. Where property damage was not recent, flood insurance sales were either minimal or nonexistent. Flood experience, defined as a function of flooding episodes at home, is related in part to damage. Homeowners close to the river and the lower-lying floodplain experience both the greatest flood frequency and the most elevated damage. Consequently, the level of insurance adoption increased directly with the number of times a homeowner's residence had been flooded. Decisions to buy insurance were also related to annual income, especially when property damages exceeded the Federal forgiveness level of $5000. At this threshold, where Federal disaster assistance did not reimburse for personal flood loss, higher-income families purchased more widespread coverage than lower-income households. Insurance buyers also perceived their damage as severe and believed that future floods would cause significant personal loss.

Two major floods within three years promoted the sale of flood insurance in Selinsgrove to the extent that over 95 percent of the persons recently surveyed are covered. Throughout Pennsylvania the picture is significantly different. The number of policies has declined steadily each year despite various state media campaigns and public service broadcasts. The number of persons insured as of 1 July 1981 was 80,889 compared to 125,000 state residents during the summer of 1977. The rate of insurance non-renewals will probably intensify as time diminishes memory of the flood. The viability of a voluntary national insurance program remains speculative in the absence of recent flooding. Consideration of a compulsory insurance program, at this time, deserves serious attention.

FLOODPLAIN COMMITMENT

The decision to remain at the flood-damaged residence despite the possibility of future flooding can be conceptualized as floodplain commitment. Residents were asked if they would be willing to relocate from the floodplain if comparable housing and property could be provided. Replies showed more persons willing to move today than after the Agnes flood. The number of persons not willing to move has decreased substantially. Those respondents displaying the most uncertainty about whether or not to move more than tripled.

Homeowners willing to move typically suffered substantial dollar damage from flooding. Over 80 percent of this group sustained damages exceeding $5000 from tropical storm Agnes. More recently, two-thirds of the residents experiencing property losses greater than $1000 from Eloise were potential candidates for relocation.

In addition to elevated dollar damage, the threat of personal flood losses is strong. For persons most strongly committed to remaining on the floodplain, environmental amenities and family ties are the strongest reasons. While the importance of family ties is spread evenly throughout all neighborhoods, the importance of river scenery remains a positive attraction for homeowners located on Front Street. On this street paralleling the

Participation in the National Flood Insurance Program encourages communities to manage flood-prone areas in a manner designed to minimize future losses. Such management may serve to keep undeveloped land such as this for agricultural use.

This unoccupied house is one of the few vacant dwellings on the Isle of Que. Virtually all homes damaged during the Agnes (1972) and Eloise (1975) floods have been repaired or reconstructed.

Susquehanna River only four of the 17 residents interviewed are willing to consider moving. The prevailing belief for the majority here is clearly that the flood hazard is not sufficient reason to leave.

The majority of property owners who have indicated a willingness to move continue to reside on the floodplain. In fact, over 72 percent of the single family homeowners have lived in their present homes 20 years or more. Even though a large pool of potential relocatables exists, strong financial and economic constraints militate against their leaving. Many homeowners, for instance, are retired with low income. Others have their homes paid for and believe that floods have significantly depreciated real estate values. The high cost of very limited housing elsewhere in this college town creates additional barriers.

In contrast to owners of riverfront homes, those individuals residing on streets away from the Susquehanna indicated a greater willingness to relocate.

PUBLIC POLICY IMPLICATIONS

Federal flood policy after tropical storm Agnes encouraged rebuilding on flood-damaged sites. Not only did the government "forgive" the first $5000 of every flood loan, it charged a nominal one percent interest on all money borrowed over that amount.

Today, the widespread availability of flood insurance is a significant factor in hardening existent floodplain residential patterns. Specifically, 30 percent of those willing to relocate indicate that having flood insurance has made remaining at home possible. This number of respondents represents a sizable minority of households sampled. Of those who are undecided about moving off the floodplain, 54 percent cite flood insurance as influencing their decision to remain where they are.

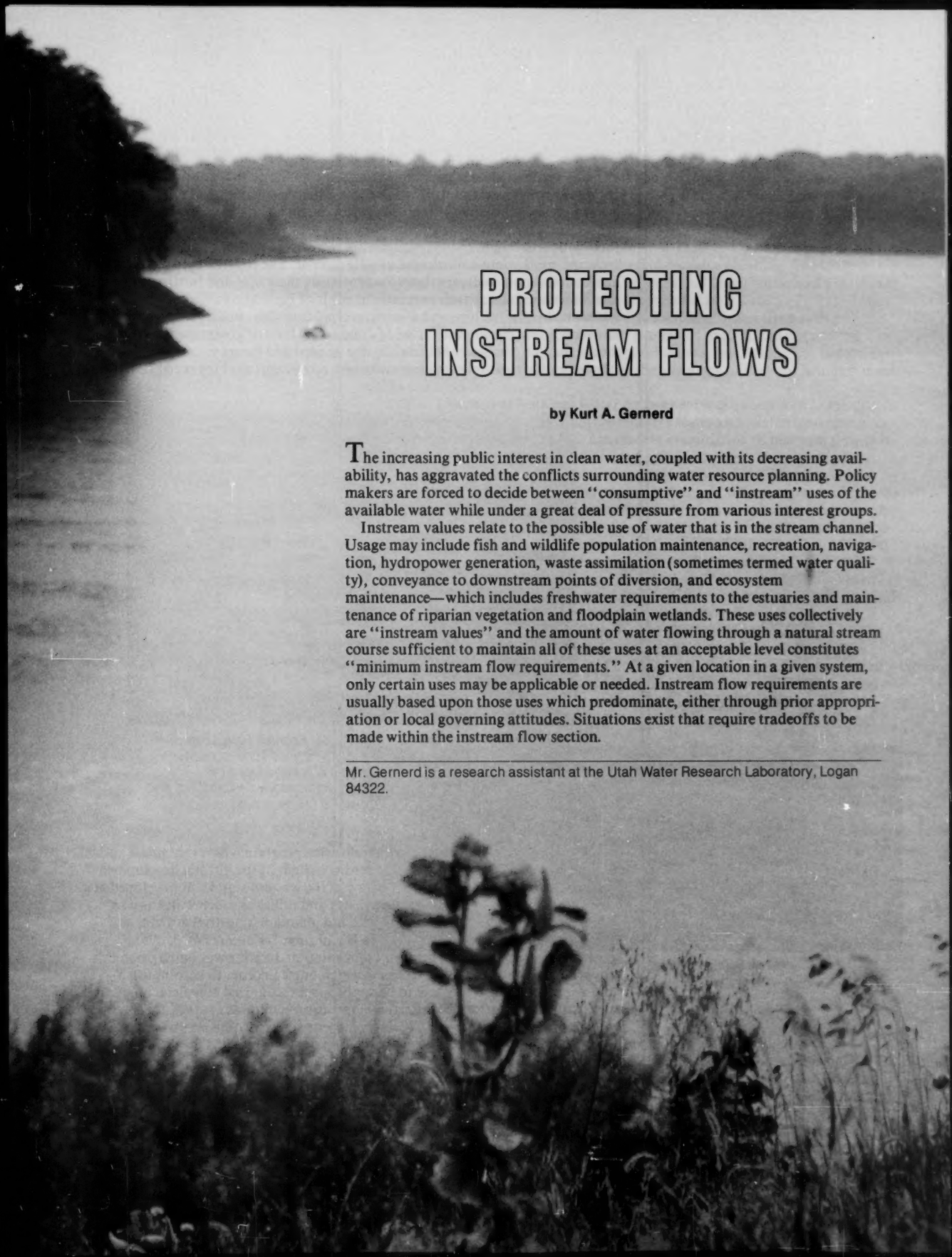
The heavily subsidized national flood insurance program is economically advantageous to all homeowners. Annual premium costs borne by the individual, at the first layer of coverage, bear no relationship to the actual risk incurred. Some economists describe this plan as a real estate tax combined with a subsidy to those who invest in risk areas where the subsidy increases with the risk of flood.

The willingness of more than half the homeowners to move voluntarily from the floodplain justifies the need for serious attention to be given this management option. Consideration of compulsory flood insurance participation may likewise heighten the desire to move from the hazard zone. Federal assistance to insured homeowners could be in the form of reduced-interest mortgages on homes purchased beyond the floodplain. Revenues generated from the pool of insurance premiums could serve initially to fund the program. Lending institutions, acting as government agents, are best equipped to handle loan transactions. Evaluation of this proposal may be possible by means of a pilot project in two communities, with program eligibility restricted to persons residing in the 50-year floodplain before the date compulsory insurance takes effect.

A second and more limited approach for relocation could have local political units securing grant money from the Department of Housing and Urban Development's nondiscretionary fund under the Community Development Block Grant Program. One Pennsylvania community has successfully combined this financial assistance with a matching grant from the state Department of Community Affairs to effect the removal of about 40 families, individuals, and businesses from the floodplain. Additional funding combinations may be relevant in other states.

As the nation enters the 1980s a broadened range of behavioral alternatives exists in the management of floodplains. Preference in the choice of strategies adopted can be effectively shaped by attention to public attitudes, values, and perceptions. Innovative methodologies will be required in this assessment, and to this end interdisciplinary research must be directed. ■

New building styles incorporate floodproofing designs by elevating the first floor of the living area above the 100-year flood level.



PROTECTING INSTREAM FLOWS

by Kurt A. Gernerd

The increasing public interest in clean water, coupled with its decreasing availability, has aggravated the conflicts surrounding water resource planning. Policy makers are forced to decide between "consumptive" and "instream" uses of the available water while under a great deal of pressure from various interest groups.

Instream values relate to the possible use of water that is in the stream channel. Usage may include fish and wildlife population maintenance, recreation, navigation, hydropower generation, waste assimilation (sometimes termed water quality), conveyance to downstream points of diversion, and ecosystem maintenance—which includes freshwater requirements to the estuaries and maintenance of riparian vegetation and floodplain wetlands. These uses collectively are "instream values" and the amount of water flowing through a natural stream course sufficient to maintain all of these uses at an acceptable level constitutes "minimum instream flow requirements." At a given location in a given system, only certain uses may be applicable or needed. Instream flow requirements are usually based upon those uses which predominate, either through prior appropriation or local governing attitudes. Situations exist that require tradeoffs to be made within the instream flow section.

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THE ISSUE

Water resource development has often reduced the quantity and subsequently the quality of the natural flows of streams. There is a widespread failure of governments in the United States to protect the many instream uses of water against intensive development for off-stream uses. When consumptive use conflicts with instream use, it may jeopardize recreation, hydropower, groundwater recharge, aesthetics, and fish and wildlife habitat. The conflict between establishment of minimum instream flows for protecting these uses and further water and related land resource development demands is of Federal significance. Some states and local governments have begun to address this conflict by preserving instream flows, but too little is being done at any level of government to bring these values into balance. Meanwhile, the present and future values of many streams and of their related lands and water ecosystems are bing sacrificed.

Fly fishermen in Diamond Fork Creek, near Spanish Fork, Utah. Maintaining an adequate base flow sustains good survival habitat for most aquatic life forms. Water depth is provided for trout movement, spawning, incubation, and winter survival in most run and pool areas of this stream. (Photos courtesy of Utah Water Research Laboratory.)

BACKGROUND

That some western states lack a comprehensive program which recognizes and protects instream values is not too surprising in light of the historic development of western water law. The basic water law of the western states was developed at a time when the prevailing theme was to divert and utilize as much water as was necessary to sustain agriculture, promote and maintain industrial growth, and satisfy community needs (*see "Western Water Law," Vol. 11, No. 3,* Water Spectrum, *Summer 1979*). The prior appropriation doctrine was based upon this concept of diverting the water from the watercourse in order to accomplish a valid appropriation. Water had to be applied to a recognized beneficial use, and, since many states defined beneficial use only in an economic context, the use of water to maintain a fishery or to preserve the stream environment was not considered valid. Nevertheless, the appropriation doctrine remains the principal system by which western states allocate the use of water to private parties.

The water law of England and the eastern states in the nineteenth century was the "riparian" doctrine, which provides that each person owning land adjacent to a stream is entitled to make "reasonable use" of the water along the flow of the stream. Rainfall is a substantial source of water in the eastern states, enough to make irrigation unnecessary in most agricultural pursuits, so little conflict has arisen concerning instream flow requirements there.

Efforts by the western states to protect and preserve instream values as part of their water resource programs have only in the past several years become a matter of concern. The only way states or special interest groups can protect instream flows is through the legal system.

In recent years litigation over environmental issues has increased rapidly and has added to the time and expense involved in resource planning. The United States Supreme Court recently held in *California v. United States* that a state may place reasonable conditions upon water right permits for water in Federal projects and may, within limits, control the distribution of water from such projects.

The First National Water Assessment, completed in 1968, did not address instream flows because of a lack of comparable data, but stated ". . . in future assessments, a more complete analysis of the adequacy of flow for instream uses will be undertaken."

In 1974, The Second National Water Assessment was undertaken to identify the most severe problems affecting the nation's water and related land resources. This assessment provided the first nationwide examination of instream flow conditions and the implications of accelerated off-stream uses. The plan of study called for a volumetric analysis of the consumptive and nonconsumptive water "requirements" in relation to water supply for each of 106 aggregated subregions or "assessment" subregions. An assessment subregion is a river basin or a group of river basins. As input to the volumetric analysis, a set of numbers was needed to represent instream flow requirements for fish and wildlife. The U.S. Fish and Wildlife Service was assigned to develop these needed numbers.

For much of the nation, there were almost no satisfactory biological data to correlate hydrological data: The data from the large assessment subregions could only indicate conditions in the stream reach near the outflow point(s), and methodologies for quantifying stream flow requirements were not adequate. However, approximations were made to assure that the instream flow values would be considered in the analysis. The Second National Water Assessment provided a major stimulus to select or develop a set of methodologies which could provide approximations of the flow requirements for instream uses.

Grassy Tail Creek, Utah. Minimum instantaneous flows must be able to sustain short-term survival habitat for most aquatic life forms.

Most states now recognize that the protection of instream values is a matter that has been neglected in their overall water resources programs. Considerable public outcry has shown the states that the use of water to sustain fish and wildlife and to provide recreational opportunities for their residents is important. In some states, competition from energy production, irrigation, and public supply demands has prevented the adoption of effective programs to protect instream values. In other states this competition has limited instream protection to modest efforts.

PRESIDENT'S INSTREAM FLOW TASK FORCE

Former President Carter sent his Water Policy Initiatives to Congress on June 6, 1978. The presidential initiative contained five directives pertaining to instream flow problems and their resolution:

1. Federal agencies shall improve, where possible, the operation and management of existing water resource projects to protect instream flow uses.
2. While not interfering with state laws and responsibilities, Federal agencies shall set a strong example in recognizing and protecting legitimate instream flow needs.
3. In planning, Federal agencies shall establish and provide for flow necessary to maintain instream needs below proposed dams or other facilities.
4. For existing water projects that lack provisions for maintaining instream flow, and where commitments and economic feasibility permit, Federal agencies, working in cooperation with the states, shall develop legislative amendments to correct this situation.
5. Agencies will provide increased technical assistance to the states in a cooperative effort to maintain necessary instream flows.

As a result of these directives, several task forces were created to carry out the president's orders. One task force was assigned to investigate instream flows and initiated six major areas to address:

1. Advise the 50 state governments of the president's instream flow directive; assist in making information and technical data available.
2. Request Federal water resource planning agencies to review their procedures to insure that they provide for the maintenance of adequate instream flow below proposed dams and other water resource control facilities.
3. Develop guidelines to determine instream flow for water quality, aesthetic, fish, wildlife, and recreation values.
4. Request agencies to identify, in cooperation with the states: (a) existing projects where instream flow is a problem; (b) corrective measures agencies plan to take, such as operation and management techniques or legislative actions; and (c) when the corrective measures will be taken or techniques implemented.
5. Identify legislation that provides general authority to agencies to protect and maintain instream flow and advise agencies.
6. Request water planning agencies to review existing authorizations to determine if the agency has adequate legislative authority to maintain instream flow at existing facilities. Where there is not adequate authority and where commitments and economic feasibility permit, the agency, in cooperation with the affected state, shall develop legislative amendments to correct the situation.

Heavy emphasis was given instream flows. Federal agencies were to set a strong example in recognizing and protecting legitimate instream flow needs. If it was deemed necessary, existing water projects would be amended to provide instream flows. The president called upon state governors and Congress to work with Federal agencies to protect fish and wildlife and other values associated with adequate instream flows. Increased cooperation in designing and operating Federal water facilities by all governmental agencies was a prime objective. States, water resources agencies, and individuals and interest groups all were encouraged to participate through this multi-agency Federal approach in working toward a solution to the problem of protecting instream flows.

NATURE OF THE PROBLEM

The issue of instream flows is usually not a clear-cut one of benefits and costs. In the west, the legal water law doctrines and water distribution systems have historically favored out-of-stream uses. Confusion and misunderstanding between various publics and water management and environmental resource agencies are increasing about definitions of, criteria for establishing, and methodologies or means of protecting instream flows. The use of the term "minimum flow" has created problems. Instream flow assessments have traditionally arrived at a single stream flow value—a minimum flow. Such recommendations are usually determined solely from analysis of hydrologic records. Developers have overused this term to describe the ultimate minimum they must leave in the stream.

Clair Stalnaker clarifies these inherent problems in developing adequate instream flows in "Instream Flow MYTHodologies and Water Management Uncertainty" (Cooperative Instream Flow Service Group, U.S. Fish and Wildlife Service, Fort Collins, Colorado. FWS/OBS–79/03, August 1979). He identifies several myths associated with instream flows and suggests bases for their being dispelled to help decision makers better assess related activities and issues of instream flow:

MYTH 1 – The minimum flow. A consistent methodology cannot be used to establish the desired minimum flow. A single flow figure is not practical. The minimum flow is not flexible and does not meet all the desired environmental needs.

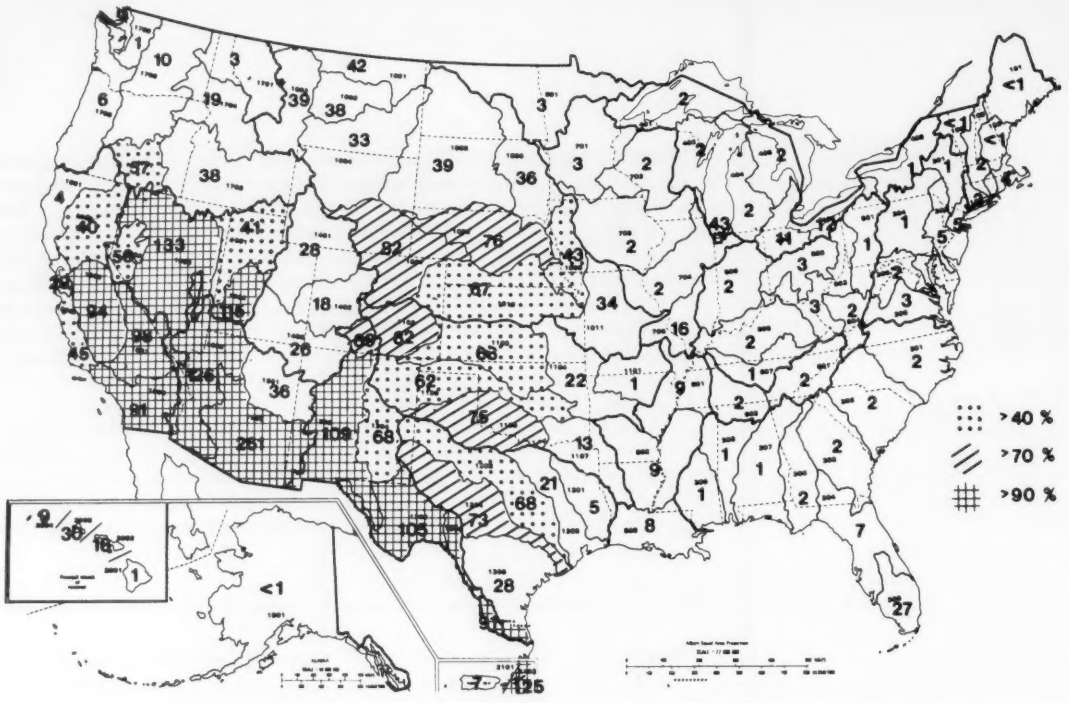
MYTH 2 – Fish flows satisfy all other instream needs. Flow requirements make up the total instream flow regime associated with a given stream reach and water yield condition. The more that is known about these situations, the more it is clear that fish flows may not satisfy all uses.

MYTH 3 – Fish need all of the water. Maintenance of the fishery may require all of the water none of the time, and the timing of flow needs is a function of management decisions regarding the desired levels of fish production and yield.

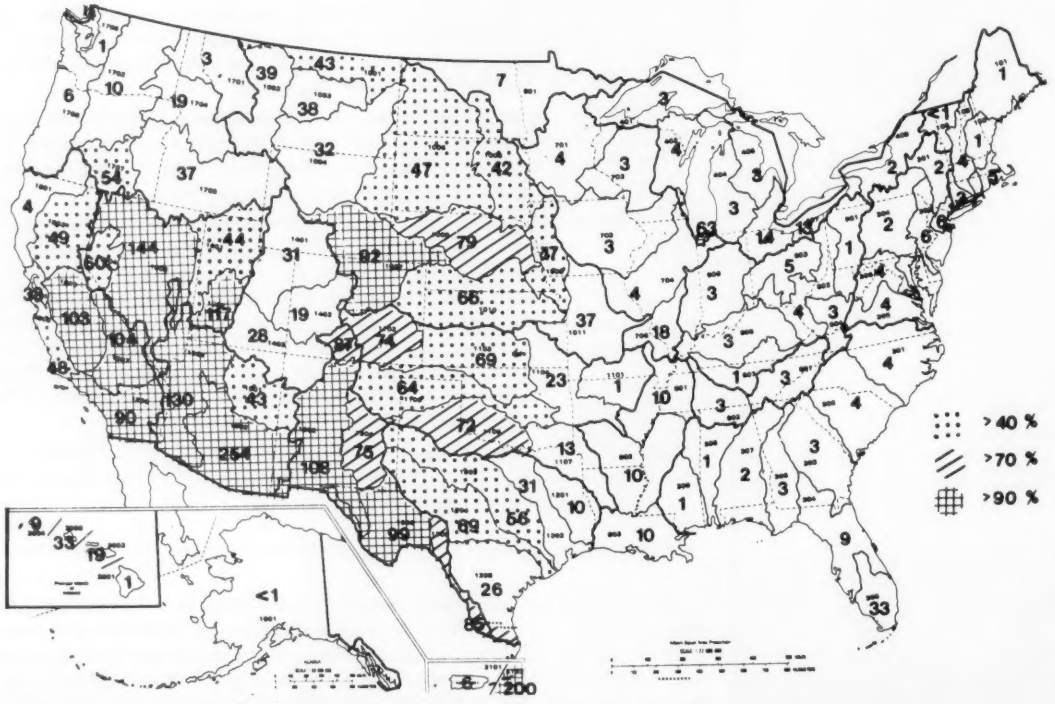
MYTH 4 – Water quantity is directly related to numbers of fish. The timing of stream flows (hydrograph and duration curves) and the distribution of the hydraulic characteristics (depth and velocity) throughout a stream reach is not sufficient to describe fish production. Actually, there are four major components of a stream system which determine the productivity of the fishery. These are (1) water quality; (2) watershed inputs in the form of sediments, particulate organic matter, and nutrients; (3) flow regimes; and (4) physical habitat structure.

MYTH 5 – Instream needs will take away all water rights. Actually recognition and quantification of instream uses pose no real threat to existing water rights.

Instream flow advocates must be better informed about legal means to protect instream flows, working within the decision making and administrative processes. The many complex issues concerning water management make it essential that effective negotiation for instream flow protection be implemented at all levels of planning. Through water management the nature of instream uses can be recognized in developing plans for various water supply conditions which equitably distribute the losses among all uses, both instream and out-of-stream, during all times of the year and especially during low-water years.



Assessed 1985 streamflow depletion ratio (%) — average year — indicating relative instream flow conditions.



Assessed 2000 streamflow depletion ratio (%) — average year — indicating relative instream flow conditions.

LEGISLATIVE ACTS AND EXECUTIVE ORDERS

Logan River, Utah.

There is much Federal legislation which provides either directly or indirectly for the protection and maintenance of instream flows for environmental and aesthetic values. These legislative acts and executive orders establish environmental protection and preservation goals and objectives along with standards for their achievement. There are also legislative acts which establish procedural requirements for the consideration and evaluation of environmental needs.

LEGISLATIVE ACTS AND EXECUTIVE ORDERS

P.L. 89-669	Rare and Endangered Species Act
P.L. 95-632	Endangered Species Act Amendments
P.L. 90-452	Wild and Scenic River Act
P.L. 95-217	Clean Water Act of 1977
P.L. 92-532	Marine Protection, Research and Sanctuaries Act
P.L. 93-205	Conservation, Protection and Propagation of Endangered Species
P.L. 93-359	Game Fish Research Act
P.L. 94-579	Federal Land Policy and Management Act of 1976
P.L. 89-90	Water Resources Planning Act (Section 103 establishing Principles and Standards)
E.O. 11990	Protection of Wetlands
P.L. 85-624	Fish and Wildlife Conservation and Resource Development Coordination Act
P.L. 89-72	Federal Water Project Recreation Act
P.L. 91-190	National Environmental Policy Act
P.L. 92-583	Coastal Zone Management Act

All Federal agencies and Federally assisted programs and projects with responsibilities for and related to water and associated land resources must adhere first and foremost to the planning requirements of the Water Resources Principles and Standards, the National Environmental Policy Act of 1969, and related policies.

STRATEGIES FOR RESERVING INSTREAM FLOWS UNDER EXISTING LAWS

The U.S. Fish and Wildlife Service, through its Western Water Allocation Project, contracted with Richard Dewsnup and Dallin Jensen to identify available strategies under state laws, Federal laws, interstate compacts, and water quality laws for reserving instream flows for fish and wildlife. The body of their report[1] contained descriptions of 26 strategies for reserving instream flows under existing laws. These are only a few of many possible strategies but they are among the most promising for obtaining results. These strategies may suggest a starting point.

Logan River, Utah. Width, depth, and velocity are physical instream flow parameters vital to the well-being of aquatic organisms and their habitat.

CONFERRING APPROPRIATIVE WATER RIGHTS

Strategy 1: Obtaining an appropriation from the state water rights agency for fish and wildlife purposes. Applying to an administrative agency for reservation of instream flows for fish and wildlife purposes. Obtaining instream flow rights through appropriations by a state administrative agency.

Strategy 2: Enhancing instream flows through condemnation and reallocation of existing rights.

RESTRICTING APPROPRIATIVE WATER RIGHTS

Strategy 3: Encouraging the state water permit authority to take advantage of discretionary opportunities. Supporting utilization of statutory criteria to protect instream flows. Encouraging imposition of conditions on water use permits to protect instream flows. Encouraging state administrative agencies to promulgate regulations to protect minimum stream flows when water rights are transferred and exchanged.

[1] Dewsnup, R.L. and Jensen, D.W., "Promising Strategies for Reserving Instream Flows." Western Energy and Land Use Team, Fort Collins, Colorado. FWS/OBS-77/29, October 1977.

LEGISLATIVE, JUDICIAL AND ADMINISTRATIVE CONTROLS

Strategy 4: Obtaining a moratorium on new appropriations.

Strategy 5: Enhancing instream flows through contractual arrangements under state law.

Strategy 6: Adopting interagency agreements, regulations and formal procedures to implement the fish and wildlife coordination act and assist in reserving instream flows.

Strategy 7: Identifying instream flow requirements of endangered species as part of critical habitat determination.

Strategy 8: Inclusion of streams within a wild and scenic rivers system to promote instream flow reservations.

Strategy 9: Legislative designation of important fishery streams to provide for water appropriations.

Strategy 10: Utilizing water quality laws for the purpose of protecting instream flows and enhancing fishery resources.

Strategy 11: Obtaining reservoir space and protective devices for fisheries in dams and reservoirs constructed or licensed under state law.

Strategy 12: Stipulations in new and renewed licenses and permits to reserve instream flows.

Strategy 13: Reauthorization of existing projects to provide for instream flow reservations.

Strategy 14: Utilizing the public trust doctrine to secure instream flows.

RESOURCE PLANNING AND MANAGEMENT

Strategy 15: Participation in statewide water planning to ensure that instream values will be protected with other water uses.

Strategy 16: Emphasizing instream flow needs in Water Resources Council planning programs toward promoting reservations.

Strategy 17: Achieving instream flow reservations by presenting recommendations early in the decision process.

Strategy 18: Utilizing the capability of the United States Geological Survey for gauging and monitoring stream flows.

Strategy 19: Analysis of water rights records as an aid to reserving instream flows.

Strategy 20: Utilizing Federal funding programs in a manner which will emphasize instream flows.

Strategy 21: Use of Federal aid funding to purchase reservoir storage as a means of reserving instream flows.

Strategy 22: Negotiation for reservoirs to facilitate instream flow reservations.

ENGINEERING ALTERNATIVES

Strategy 23: Conveying stored water to downstream users via the stream channel to aid in securing instream reservations.

Strategy 24: Providing for reservation of instream flows by increasing the availability of water for this purpose.

Strategy 25: Coordinated operation of multi-reservoir systems to facilitate instream flow reservations.

Strategy 26: Releases from reservoir sediment storage reserves to promote instream flow reservations.

Coal Creek, Carbon County, Utah. Severe climate limitations, along with agricultural and energy development water demands, synergistically contribute to the disruption of surface flows.

Looking southeast into Settlement Creek Canyon, Utah. Water storage augmented with regulated flow releases can insure adequate instream flow conditions year round.

CONCLUSION

The decision on whether the public or private sector should be responsible for protecting instream uses of water seems to rest on two basic assumptions. The first of these assumptions is that water is a resource which should be allocated in the atmosphere of a free market system. People who believe that water flowing in the stream channel will have a greater value in the future will purchase a share of this resource. This is sort of an investment in which the purchaser can retain his right for the future or sell the right for immediate return on his investment. By this mechanism the water will be preserved into the future.

The second assumption is that flowing water is a public resource and has public values. Individuals or small groups do not have enough power to protect instream flows. Therefore this assumption is used on the state level to pass legislation that protects instream flows through administrative regulations.

Until recently development was thought to be good no matter what the costs. Over the past 20 years this development ideology is dying out and being replaced by the best use and preservation value systems. The demand for public protection of instream flows has increased and instream flows are now generally accepted as a beneficial use.

Private parties have tried to protect instream values in several states. In Colorado, the stream flow through the city of Boulder was protected for aesthetic values by exchange with agriculture users. This involved the negotiation of an exchange of water rights and new release patterns from a reservoir to assure that water flowed through the city at low flow periods.

Washington, Oregon, Montana, Idaho, California, Wyoming, Arizona, Colorado, and North and South Dakota have specific elements in their statutes which provide reservation or protection for instream uses. Utah, New Mexico, and Nevada have no statutory or administrative provisions for the condemnation of existing water rights to reserve instream flows other than by their state game commissions which have the right to secure water rights for the preservation of wildlife. The states seem to be committed to allocating water through private diversion appropriations and public storage projects. This means that in all states the protection of instream values is a politically volatile issue, and in some states it is nearly impossible for the states to protect instream values.

The Reagan administration is still very much involved in the budget and new organization. The present effort mainly concerns revisions and further analysis of water projects, with a higher proportion of water being sold to the energy industry and for municipal and industrial purposes.

A task force on water policy, however, has been established. The task force is made up of the Assistant Secretaries of Interior, Agriculture and Army, along with officials from the Environmental Protection Agency, the White House, and the Office of Management and Budget. They will be recommending water policy reforms to the Cabinet Council on Natural Resources and the Environment. The task force will be headed by Interior Secretary James Watt.

Secretary Watt has reportedly picked several water-related issues for attention by the cabinet council which will be considered by the task force. These include large water projects, coastal zone management, deregulation, barriers to energy development, stream management, and water development. ■

Events, Deeds & Deliberations

ELLIS ISLAND PRESERVATION

In an effort to save deteriorating historic immigration structures at Ellis Island, the National Park Service (NPS) is soliciting proposals from private sources to preserve some of the structures and convert them to appropriate private use.

Ellis Island, in New York Harbor, was a Federal immigration station between 1892 and 1954 and the first stop for some 12 million newcomers to America. The island came under NPS jurisdiction in 1965 when it was added to the Statue of Liberty National Monument. But, because so many of Ellis Island's 33 buildings are badly run down, much of the island has been off limits to the public.

Under the NPS plan, the Park Service would preserve and expand visitor services in the three structures that figured most prominently in the immigration story: the main immigration building, the baggage and dormitory building, and the kitchen and laundry facility. Most immigrants never entered the remaining 30 buildings, which include a hospital and contagious disease wards. These buildings, which contain 337,980 square feet of interior space, would be leased to a private profit or non-profit bidder that develops an acceptable plan for preservation of the buildings' facades and adaptive use of the interiors.

The buildings could be put to commercial, manufacturing, light industrial, office, hotel or other uses "that are compatible with the NPS mission, are non-polluting and will not interfere with public visitation to NPS-operated areas," says NPS Director Russell E. Dickenson.

"This plan allows for more extensive preservation of structures on the island than the government could afford to undertake on its own," he said. "Without private participation, preservation of many of them would have to be postponed indefinitely, and if no action is taken, some will deteriorate past the point of rehabilitation." he said.

"Non-governmental uses of the site that provide direct support for preservation of historic areas are timely, and, as yet, unexplored," Dickenson said. The Historic Preservation Act Amendments, passed in 1980, gave the NPS authority to lease historic structures as long as the property is adequately protected.

Dickenson emphasized that the lease arrangement is not for visitor services—which will be provided either directly by the NPS or through the existing concession contract covering the Statue of Liberty National Monument. The NPS has also ruled out development of an amusement park on the site. □

PACIFIC COAST ECOLOGICAL INVENTORY AVAILABLE

The Interior Department's U.S. Fish and Wildlife Service has published a major new planning tool showing the important fish and wildlife species of the Pacific coastal zone. As the first comprehensive series of natural resource maps of the west coast depicting fish and wildlife and their habitats and major land use designations, the "Pacific Coast Ecological Inventory" is designed for use by local and state governments and industries that contemplate major developments in the coastal zone.

The Pacific guide follows last year's "Atlantic Coast Ecological Inventory," which has been cited for its usefulness in providing resource information to developers before irretrievable commitments of time and money are made during the planning stages of coastal zone projects. Development planners have applied the map series in designating areas of special concern for fish and wildlife during projects' siting and design stages. In addition, the Federal government's national response team for spills of oil and hazardous substances has used the Atlantic Coast map series to plan cleanup activities in areas where important fish and wildlife species have been pinpointed.

The 30-map "Pacific Coast Ecological Inventory" depicts the entire 40,150-square-mile Pacific coastal zone from Mexico to Canada, including Puget Sound. It is now possible, at a glance, to select any site from California to Washington State and locate on a 1:250,000 scale map (one inch equals about four miles) any of 356 important fish and wildlife species that use the area (such as endangered species, migratory waterfowl, and commercially important fish populations). The different land use designations nearby (national wildlife refuges, state waterfowl management areas, and national and state parks) are also included.

The Interior Department's U.S. Geological Survey provided technical assistance in producing the map series. Species data, along with the special land use designations, are plotted on topographic base maps, which carry the same individual section names as the Geological Survey's standard topographic map series (Crescent City, San Clemente Island, San Diego, Santa Ana, Long Beach, Santa Rosa Island, Los Angeles, Santa Maria, San Luis Obispo, Monterey, San Jose, San Francisco, Sacramento, Santa Rosa, Ukiah, Redding, Weed, Eureka, Medford, Cape Blanco, Roseburg, Coos Bay, Salem, Vancouver, Hoquiam, Cape Disappointment, Seattle, Copalis Beach, Victoria, and Cape Flattery).

In addition to the maps, a 159-page narrative report, "Pacific Coast Ecological Inventory—User's Guide and Information Base," is also available. This report is designed as a companion to the map series, providing detailed explanations and additional technical information about the ecological data displayed on each map.

"Pacific Coast Ecological Inventory" maps are available individually, or in 30-map sets, at $3.25 per map. They can be ordered from the U.S. Geological Survey, Branch of Distribution, Box 25286, Federal Center, Denver, Colorado 80225. Particular map sections desired must be specified.

The accompanying narrative report can be ordered from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $5.50 (specify stock # 024-010-00596-3). □

INJURED MANATEES RELEASED

For the first time ever, two injured manatees were successfully released to the wild in Florida after being rehabilitated in captivity. One of the large, docile "sea cows" was injured when she became entangled in a crab trap line, which wrapped tightly around her flippers. She was treated at Sea World and released with her calf, which was uninjured but had remained with its mother throughout the ordeal. Another female manatee that apparently had been struck by a boat was rehabilitated by two other private groups, Marineland and Homosassa Springs. The oceanaria and park groups rescue injured manatees, an endangered species, under an arrangement with the U.S. Fish and Wildlife Service. □

FLOOD RESEARCH GRANT AWARDED

Scientists at the Illinois State Water Survey were recently awarded a grant of $106,600 by the National Science Foundation to prepare a comprehensive national plan of research on floods and their mitigation. The development of a blueprint to guide future research on flood issues will be the primary goal of the study. The preparation of the plan will include texts by national experts and a series of expert reviews of the planning document. The major topical areas for which research needs will be addressed include hydrology and hydraulics, meteorology and climatology, the environmental sciences, health and sanitation, law, and societal issues. □

REMOTE SENSING SYMPOSIUM HELD

The U.S. Army Corps of Engineers Remote Sensing Symposium was held 30 November–2 December 1981 in Nashville, Tennessee. Brigadier General Forrest T. Gay, Deputy Director of Civil Works, gave the keynote address. Speaking on "Today's Challenges with Remote Sensing Technology," General Gay stressed the Corps' need for accurate environmental data, which remote sensing technology can

help supply, to accomplish the Corps' water resources and military mission. The closing address was presented by Major General William R. Wray, Deputy Chief of Engineers, who spoke about the potential of remote sensing technology to assist in Corps' mission data requirements.

Field offices were well represented at the symposium, both as attendees and speakers. Topics of discussion ranged over the entire field of applications the Corps is involved in as well as new technology and future systems. The proceedings of the symposium will be published in the spring. (The summer 1982 issue of *Water Spectrum* will feature an article on remote sensing applications within the Corps.) □

PUPFISH DECLARED EXTINCT

The Tecopa pupfish has become the first species to be removed from the endangered list because it is extinct. The Interior Department's U.S. Fish and Wildlife Service made the announcement after no Tecopa pupfish were found in spite of extensive searches by Federal, state, and university biologists in more than 40 localities near Tecopa, California, where the fish could possibly have existed.

The unique desert fish, native to California's Death Valley system, was known to have lived in only two outflow springs of the Amaragosa River system. It is thought to have disappeared because of alteration of its habitat and possibly also as a result of the introduction of competing, non-native fish. One of 12 kinds of pupfishes in the U.S., the 1½-inch Tecopa could tolerate highly saline waters and temperatures up to 110 degrees. In 1965, the two hot spring outflows were rechanneled and combined during construction of bathhouses, resulting in a swifter channel which carried even hotter water farther downstream, a situation for which the pupfish was not adapted.

Virtually eliminated by 1969, the Tecopa pupfish was added to the endangered species list in 1970. By 1972, it was known to be gone from this locality, although survival of the related Amaragosa River pupfish in nearby pools and springs indicated that the Tecopa might continue to exist elsewhere in the river system.

In 1978, the Fish and Wildlife Service proposed the Tecopa pupfish for removal from the list because it was believed to be extinct; removal has been delayed until additional surveys could be completed.

"It is always sad when a species becomes extinct because of human activities," noted Robert A. Jantzen, director of the Fish and Wildlife Service. "But the Tecopa pupfish was possibly already extinct when the first recovery efforts were made under the endangered species laws. In this instance, the fact that this fish has become extinct should not be taken to mean that endangered species conservation measures have failed. On the contrary, recovery actions have benefited a great number of endangered species, such as the American alligator, peregrine falcon, whooping crane, and brown pelican." □

STUDY ON ENVIRONMENTAL DRILLING EFFECTS COMMISSIONED

The environmental effects of drilling mud discharges during offshore oil and gas drilling operations are being assessed by the National Academy of Sciences on behalf of the Interior Department's Bureau of Land Management (BLM).

Secretary of the Interior James Watt said that the study was part of the continuing effort of the Department of the Interior to protect environmental values and assure maximum safety in all Federal offshore operations.

"We are dedicated to obtaining quality scientific information and having it interpreted by knowledgeable scientists to identify any possible impacts of drilling mud discharges on the environment," Secretary Watt said.

"In the Georges Bank area offshore New England, for instance, we have established a Biological Task Force to carefully monitor exploration for oil and gas resources there to assure protections of the valuable fishery resources of the area. The assessment by the National Academy of Sciences of the effects of drilling mud discharges on the marine environment will assist us in providing for rigorous standards in an important phase of offshore development."

The drilling fluid, which consists primarily of water and the minerals bentonite and barite, is pumped down the well during oil and gas drilling to flush out cuttings and to lubricate the drilling bit. As the Federal government's mineral leasing agent, BLM is responsible for continually assessing the potential effects that offshore oil and gas development might have on marine environments.

The recently signed agreement between BLM and the National Academy of Sciences calls for the Academy's Marine Board to critically review the extensive data that have been gathered by BLM, the Environmental Protection Agency, the National Oceanic and Atmospheric Administration, and the petroleum industry since 1975.

The following questions are to be addressed in the review:

- What is the range over which the composition of drilling mud components vary under routine use? What is known about the composition of these spent fluids?
- Where drilling mud components can be distinguished from natural background in the marine environment, what have been the observed effects, if any?
- Can results and conclusions drawn from relevant past and ongoing research programs be applied to different marine environments?
- Should the existence and/or significance of cumulative effects be demonstrated by conducting a field study in a specific area? The study will also focus on engineering implications of controlling operational discharges of drilling muds. □

Bookshelf

Process Chemistry for Water and Wastewater Treatment, by Larry D. Benefield, Joseph F. Judkins, and Barron L. Weand, is a text written by engineers for engineering students and practicing engineers. Chapters 1–6 cover certain basic chemical principles; Chapters 7–14 concern the application of these principles to the understanding of a number of chemical processes commonly encountered in water and wastewater treatment. The 510-page volume is available at $29.95 from Prentice-Hall, Englewood Cliffs, NJ 07632.

The Oceans: Our Last Resource, by Wesley Marx, confronts a variety of critical environmental questions being raised worldwide: What are the possibilities for recovering minerals from the ocean floor? Are undersea cities feasible? In what ways are river dams affecting the survival of sandy beaches? What can be done to both exploit and preserve global fisheries? These and other issues are explored, in particular the opportunities to preserve and utilize "our last resource." The 330-page volume is available at $13.95 from Sierra Club Books, 530 Bush St., San Francisco, CA 94108.

Proceedings, Water Reuse Symposium II, are now available in three volumes. The symposium, held in Washington, D.C., in August 1981, addressed the major issues confronting the water supply industry in the implementation of water reuse and recycling. Renovation of municipal, industrial, and agricultural wastewater was covered from the engineering, scientific, economic, and legal viewpoints. Price is $30. Order from AWWA Research Foundation, 6666 West Quincy Ave., Denver, CO 80235.

The Bight of the Big Apple, by Donald F. Squires, traces the history of the New York bight from wilderness to thriving commerce center to current disuse. The author discusses how the bight—the big stretch of ocean between New Jersey and Long Island—influenced the development of metropolitan New York City and offers some projections for its future. The illustrated 84-page paperback is available for $3.00 from New York Sea Grant Institute, State University of New York and Cornell University, 411 State St., Albany, NY 12246.

Modern Management of Water and Wastewater Utilities, by William E. Korbitz, is a reference for utility managers on practical approaches to problems and for consultants, enforcement personnel, city councils, utility boards of directors, and students of engineering and public administration. Topics covered include water and wastewater technology, concepts of business and public administration, public and utility financing, public relations, and statute and contract law. The 273-page volume is available at $32.50 from Garland STPM Press, 136 Madison Ave., New York, NY 10016.

Papers of the Fifth Symposium on Hudson River Ecology, edited by Joseph W. Rachlin and Gilbert Tauber, contains 10 papers dealing with environmental problems in the areas of energy production, shoreline modification, water and wastewater, and fisheries. Focusing on the Hudson, the papers address problems common to coastal and river valley regions throughout the industrialized world. The 107-page paperbound volume is available at $15 from the Publishing Center, 625 Broadway, New York, NY 10012. □

Coming Events

Hazardous Material Spills Conference, Milwaukee Exposition & Convention Center, April 19–22.

9th Annual Technical Institute on Docks and Marinas, Madison, Wisconsin, May 3–5.

37th Annual Meeting of the Soil Conservation Society of America, Marriott Hotel, New Orleans, Louisiana, August 8–11.

American Institute of Chemical Engineers Summer 1982 National Meeting, Stouffers Inn on the Square, Cleveland, Ohio, August 29–September 1.

Oceans 82, Shoreham Hotel, Washington, D.C. September 20–22. □

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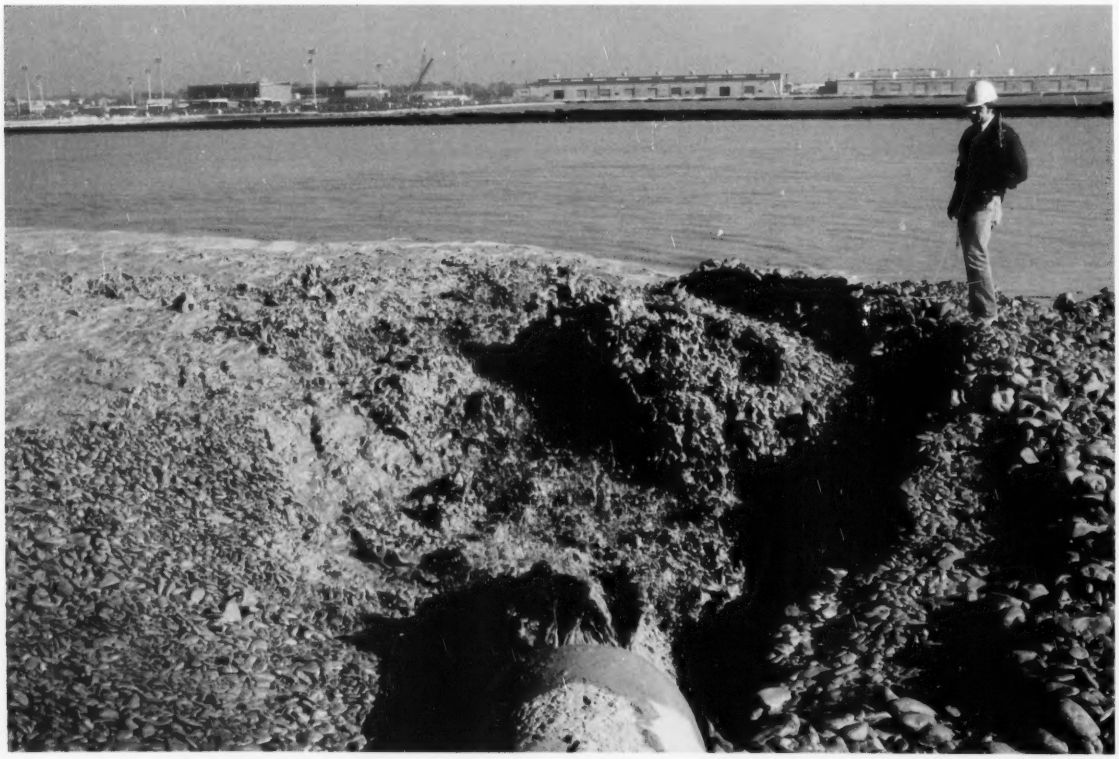
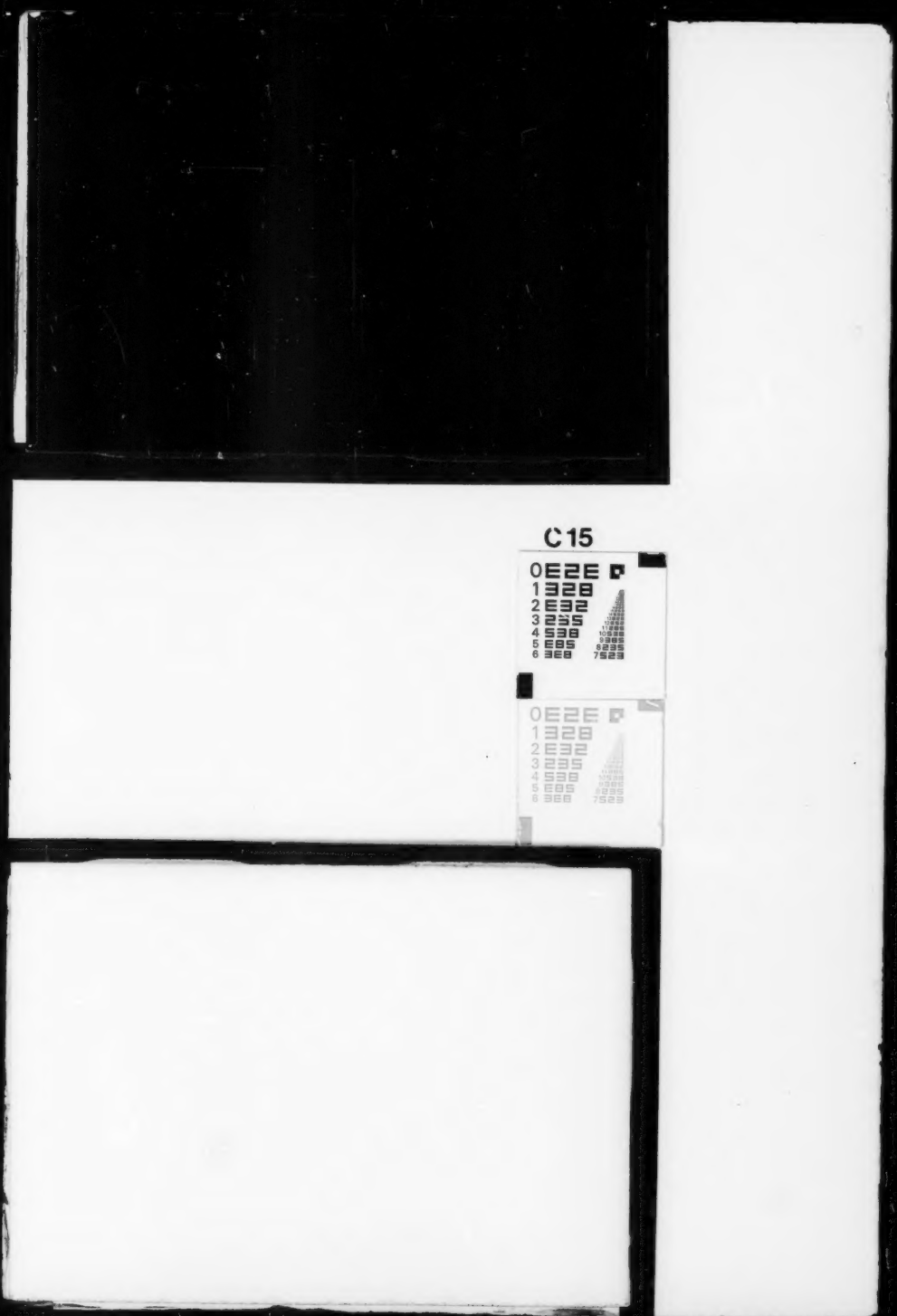
Technical representative observes discharge pipe from dredging operation for Fort McHenry Tunnel. See "Baltimore Harbor Tunnel: Maintaining Water Quality," on page 16. (Photo by Dick Brehl, Associated Photographers, Pittsburgh.)

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